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WEEKLY 26 March 2022

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This week's issue

On the cover

38 How humans learned to speak
The accidental origins of our greatest innovation

Vol 253 No 3379
Cover image: Harriet Noble/ Studio PI

10 Hawking's black hole paradox solved?

42 Why we should all be working our pelvic floor

18 Ukraine war sparks energy scramble

46 Jim Al-Khalili on how to stay curious

8 Omicron's second wave
51 Planets to spot at dawn
12 Octopus brains
54 Why the first pancake is the worst

42 Features

> "Kegels can be frustratingly difficult, like trying to isolate the right muscles to wiggle one eyebrow"

News

7 Global warming
Both poles are experiencing extreme heating

8 The pandemic isn't over
Another global wave of the coronavirus may have only just begun

15 Think again
Brain scanning studies are mostly too small to be useful

Views

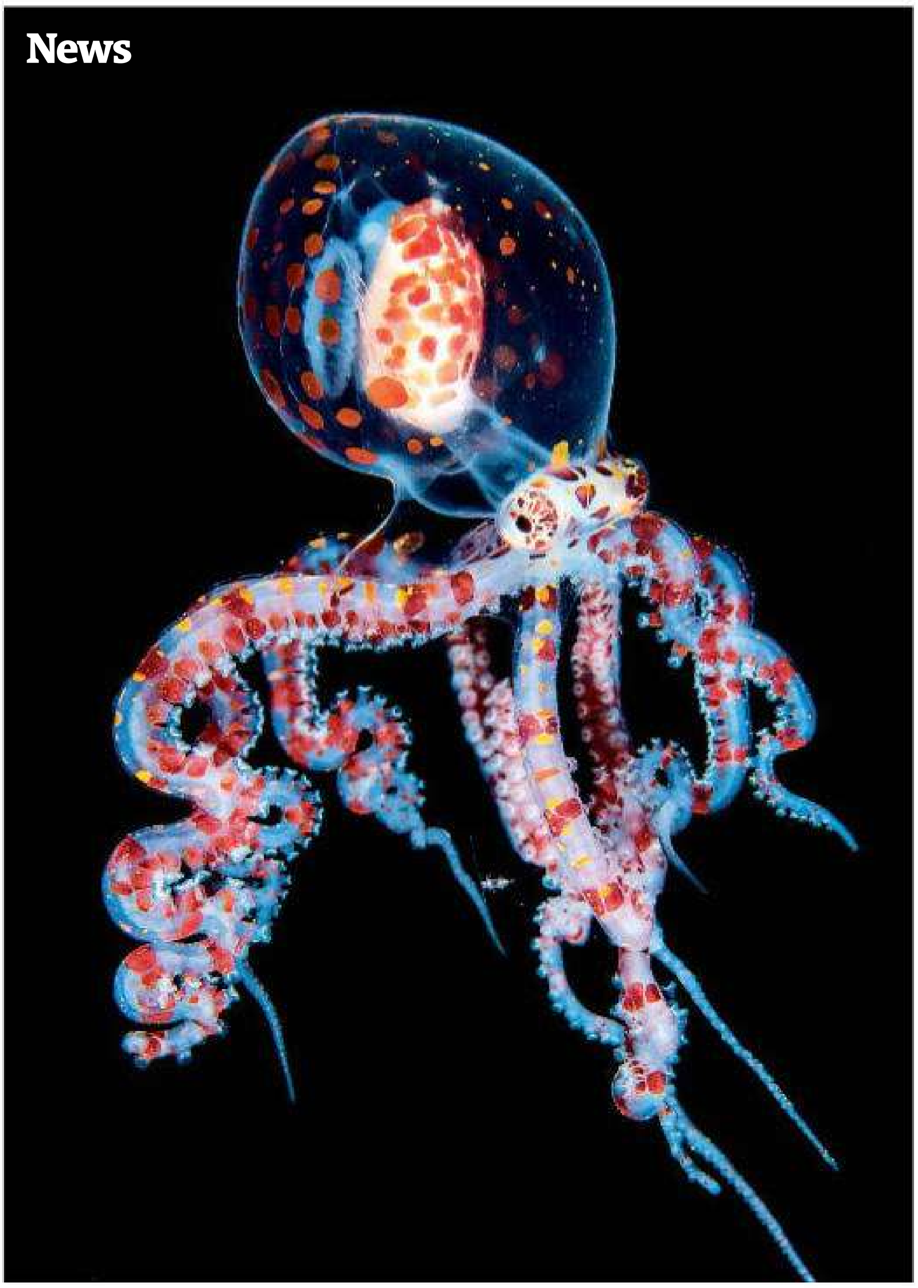
27 Comment
We must dispel the myth that science was a European invention, says James Poskett

28 The columnist
Graham Lawton on the Ukraine war's green impact

30 Aperture
A vibrant new fish species

32 Letters
We need to choose carbon capture tree species carefully

34 Culture
A true-crime series about an intriguing insect heist



MAGNUS LUNDGREN/NATUREPL.COM

12 Octopus brains The evolutionary trick that made cephalopods smart

Features

38 Playing with words
The key to understanding how language evolved is to think of it like a game of charades

42 Inner strength
Why it is time for everyone to give their pelvic floor a good workout

46 The joy of science
Jim Al-Khalili explains the importance of childlike curiosity

The back pages

51 Stargazing at home
A planet-spotting extravaganza for early risers

53 Puzzles
Try our crossword, quick quiz and logic puzzle

54 *Almost* the last word
Why is the first pancake of the batch the worst one?

55 Tom Gauld for *New Scientist*
A cartoonist's take on the world

56 Feedback
Scientists prove that boring people are boring

Elsewhere on New Scientist

Event

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Podcast

Weekly

The team discuss how Russia's attack on Ukraine could spark global food shortages, and a simple solution that could have knock-on benefits for the climate and biodiversity. As cases of covid-19 rise, they also examine the effectiveness of Iceland's "herd immunity" strategy. Plus, composer Hannah Peel shares some clips from her new music inspired by nature.

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Superfood myths Find out the truth behind the mixed messages

YORK TILLYER

Hannah Peel Listen to her new music inspired by nature

Video

Crystal clear

The James Webb Space Telescope has sent back the highest resolution infrared image ever taken from space. This incredible telescope peers into the cosmos with the help of 18 gold-plated hexagonal mirrors. Now, it has reached a crucial phase in which its mirrors are aligned with nanometre precision, so the images that are returned are clearer than ever.

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Newsletter

Brain scan bombshell

This week in her Health Check newsletter, Clare Wilson unpacks the problem with brain scanning studies after a recent analysis found that those looking at mental health or personality traits are mostly unreliable. It seems that a lot of these studies used far too few people to have a hope of finding any true results.

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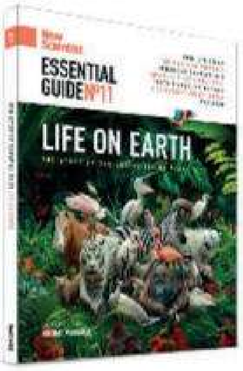
Newsletter

> "Crappy science will find whatever it's looking for"



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Share Price	6.9%	11.1%	-14.4%	23.3%	10.2%
MSCI AC Asia ex Japan Small Cap (N) Index	19.1%	-4.9%	2.5%	36.7%	6.9%

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Source: Morningstar as at 28.02.2022, bid-bid, net income reinvested.
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The new wave

Ending a global pandemic will require a global mindset

JUST over two years since the official start of the pandemic, tens of millions of people in China have entered lockdown. It is a striking reminder of how things started, and that, despite the feeling in some countries, things are far from over.

At the end of January, the huge global wave of covid-19 caused by the faster-spreading omicron variant was ebbing fast, but now cases are ticking up once more. This second wave of omicron has been caused in part by an even faster-spreading subvariant, plus the fact that many nations are dropping measures to contain the virus, as we report on page 8.

The emergence of such fast-spreading variants has shifted the pressure points of the pandemic. Many countries that took a heavy toll early on and therefore had a strong incentive to vaccinate, including England, have now chosen to drop restrictions, assuming that vaccines will keep deaths and hospitalisations low as case numbers soar.

That is in stark contrast to regions that successfully dodged a high death toll at the start of the pandemic. These include Australia, New Zealand, mainland China and Hong Kong, which kept the virus at bay with rigorous testing and quarantine measures. They were successful for a time, but the increased transmissibility of recent variants allowed the virus to break through. At this point, it is clear that public health officials in these regions must refocus efforts on vaccination.

> "The emergence of fast-spreading variants has shifted the pressure points of the pandemic"

This presents a few problems. First, not all vaccines are equal. China has been using its own vaccines, which are less effective at preventing infections than the mRNA vaccines used by many other nations. Second, vaccine access has been inequitable since jabs were first rolled out. Dozens of countries still have less than 10 per cent of their population vaccinated.

How this wave will play out in these nations will depend on several factors. But the situation reminds us what we do know for sure: that this wave won't be the last; that we cannot expect to deal with the pandemic in one corner of the globe and not see repercussions elsewhere; and that, ultimately, the only way to prevent new variants is to prevent the spread of the virus. ▮

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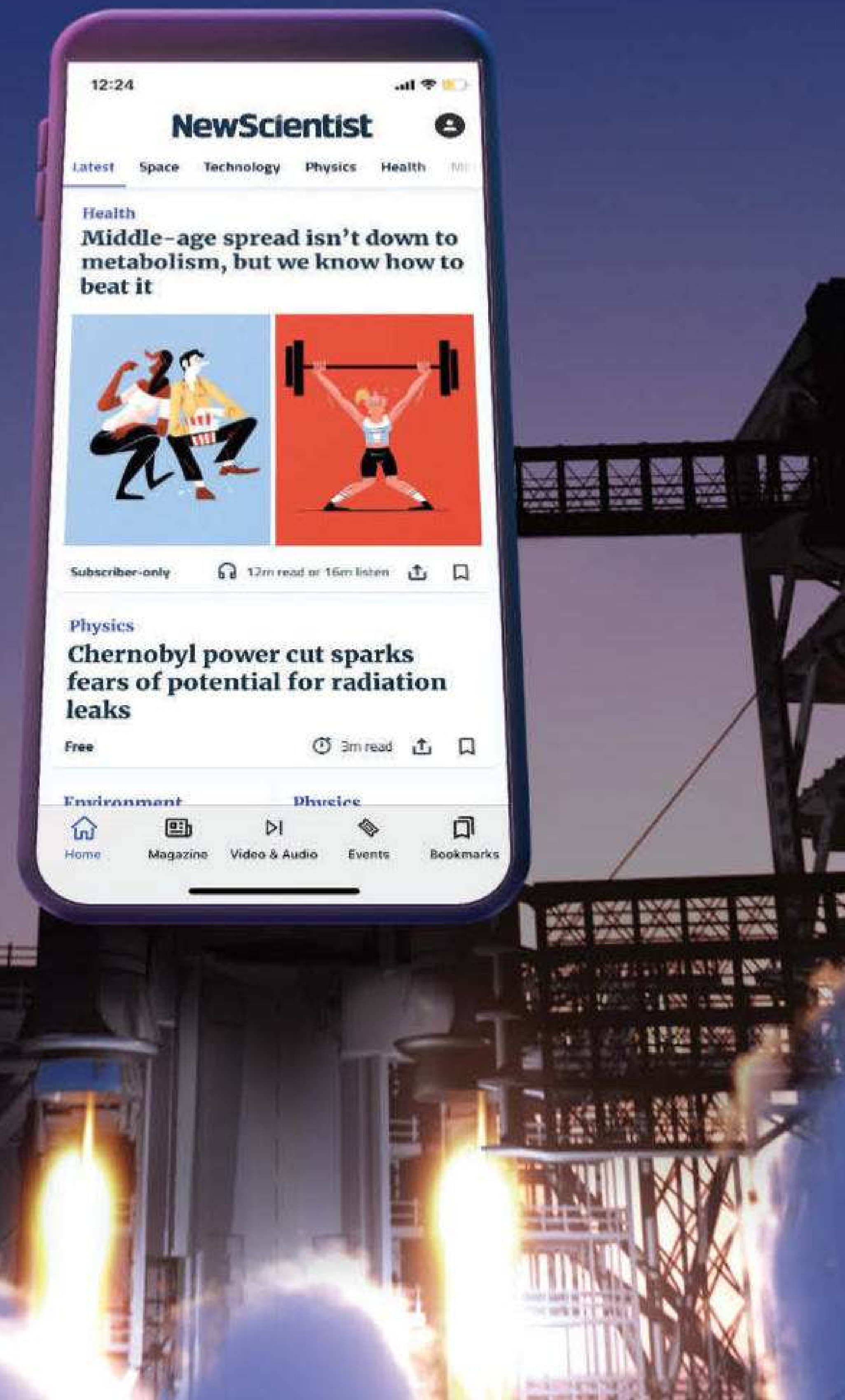

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Into the core
Magnetic waves could reveal Earth's inner secrets **p12**

Star photography
James Webb Space Telescope sends back best image yet **p14**

Winging it
YouTube video makes people think they can land a plane **p15**

Hay fever woes
US pollen season starts early due to climate change **p22**

Do look up
Small asteroid spotted just before hitting Earth **p23**

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Seals on an ice floe off Horseshoe Island, Antarctica

Environment

Extreme heat at the poles

The Arctic and Antarctic are both being warmed by hot air currents coming soon after historic sea ice lows, reports **Adam Vaughan**

ABNORMALLY hot air has hit both of the world's poles at once, while the extent of Arctic sea ice appears to have been historically low once more this winter.

Temperature records were recently broken in Antarctica as warm air swept unusually far into the heart of the continent. Concordia research station, which is high above sea level and has an annual average temperature of -50°C, reached an all-time high of -12.2°C on 18 March, beating the -13.7°C record that was set there in December 2016. Another research station, Vostok, also saw record high temperatures.

"The Antarctic [heat] is really extreme. I haven't seen anything like that. Colleagues haven't seen anything this extreme," says Walt Meier at the US National Snow and Ice Data Center in Boulder, Colorado.

A band of westerly winds around Antarctica usually isolates the continent from other weather systems. But in the past week, an "atmospheric river" of hot air, originating in the mid-latitudes, travelled down from Tasmania and South Australia, breaching those winds to travel far across the ice, says John Turner at the British Antarctic Survey.

Although such events aren't unprecedented, the temperatures are very high this time. Turner says while it is undoubtedly an "extreme event", he thinks the Antarctic heat looks like natural variability rather than climate change. Past research by Turner has found no discernible trend in extreme temperatures in Antarctica, where the cooling effect of the hole in the ozone layer appears to have cancelled out the impact of global warming so far.

The record temperatures come shortly after Antarctic sea ice declined to a record low minimum extent, at 1.92 million square kilometres on 25 February. "It was quite a lot lower than anything else in the 40-plus year record," says Ted Scambos at the University of Colorado, Boulder.

> "The Antarctic heat looks like natural variability rather than climate change"

However, he says Antarctic sea ice extent is highly variable from year to year and no downward trend has emerged yet because of climate change. The record sea ice low and recent temperatures are unconnected, he says, though he thinks if there was more ice this year, it may have blunted the impact of the warm air by drawing more moisture out of it.

Temperatures have also been unusually high in the Arctic recently, with some areas 30°C warmer than usual and the region as a whole 3.3°C hotter than the long-term average.

The cause of the heat there is a pulse of warm, moist air being sent northwards from the North Atlantic Ocean, says Meier. Such pulses of heat in the Arctic have been seen a few times in recent years, most notably in January 2016 when temperatures were up to 8°C above average.

"So this is not unprecedented, but it's certainly a strong event, and it's something that was quite rare until recent years," says Meier. There may be some surface melt at the North Pole, but the effect will be relatively small, he says.

The heat in the far north comes as Arctic sea ice has settled at its 10th lowest winter maximum on record, at just under 15 million square kilometres.

Though the ice ranking hasn't been officially confirmed yet, Meier says it is unlikely to change. "In light of the last 15 years, it's not particularly extreme. [However, it is] extreme compared to the 1980s," he says.

Unlike Antarctica, the Arctic has seen two very clear signals of climate change: the long-term decline of sea ice and temperatures rising three times faster than global increases. ▮

Coronavirus

The next big wave is coming

Cases of covid-19 are climbing sharply again, and China in particular faces a potential disaster if it fails to contain its biggest outbreak since 2020, reports **Michael Le Page**

SOME think the covid-19 pandemic is over – but it most certainly isn't. On the contrary, around the world, the number of confirmed cases is rising rapidly again. The most concerning situation is in China, where many older people still have no immune protection of any kind and which is currently battling a major outbreak. So why are cases on the rise again, how bad will it be and what could happen next?

The omicron variant that first started spreading in November 2021 caused by far the biggest wave of the pandemic to date. Globally, reported covid-19 cases peaked towards the end of January this year, and they were falling nearly as fast as they shot up. But now they have begun to rise sharply again, up by 8 per cent in the week ending 13 March according to the World Health Organization (WHO).

Because many countries are doing less testing than they did at the peak of the omicron wave, the actual increase could be even bigger than this, said WHO director-general Tedros Adhanom Ghebreyesus during a briefing on 16 March. Deaths are still declining globally, but they are expected to rise again too; deaths usually lag cases by around three weeks.

The situation isn't the same everywhere. In some nations that had big omicron waves, the number of reported cases is still falling. Notably, that includes South Africa, the first country to have an omicron wave.

The number of tests being done in South Africa has fallen sharply, from around 70,000 per day during early December to just 20,000 in early March. But the proportion of positive tests has fallen from 37 per cent to 7 per cent over this period, which indicates that case numbers really are falling.

In other parts of Africa, Europe and Asia, reported cases have begun to climb again. Some countries that had big omicron waves, including the UK, Germany and France, are seeing a resurgence before the previous wave has even subsided.

> "Lifting of the use of masks and of physical distancing provides the virus an opportunity to spread"

Breakdowns of case numbers by which virus variant is responsible show that while the initial wave of omicron was mainly caused by one of its subvariants called BA.1, the BA.2 subvariant is driving the resurgence. The term omicron refers to a whole family of related variants that appeared around the same time, rather than to one specific variant. BA.2 has been around from the start and is even better at spreading than BA.1.

"This is the most transmissible variant we have seen of the SARS-CoV-2 virus to date," said Maria Van Kerkhove at the WHO during the briefing on 16 March. A study in Denmark found that people can be infected by BA.2 less than two months after having BA.1, but this is rare and may not be a major element in the overlapping waves.

BA.2 isn't the only factor involved. "We've dropped all measures, so a resurgence is not very surprising," says Aris Katzourakis at the University of Oxford, referring to the situation in England. "Lifting of the use of masks, lifting of physical distancing, lifting of restrictions limiting people's movement, this provides the virus an opportunity to spread," said Van Kerkhove.

In contrast to some countries in Europe, South Africa has been maintaining measures, such as mask wearing in public spaces, and this might be helping to limit the BA.2 wave there. BA.2 has become the dominant variant, but it hasn't caused enough cases to increase overall case numbers.

But there is no way to be sure that maintaining measures is why the BA.2 wave is smaller in South Africa, says Katzourakis. The nation also differs from European countries in other ways, he says – for instance, most people there have acquired immunity from infection rather than vaccination.

People may also be taking fewer precautions because of the misperception that the pandemic is over and that omicron is mild, said Van Kerkhove. Omicron is less likely to cause severe disease

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A woman purchasing rapid covid-19 test kits in China

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in those infected than the delta variant. But because it is more transmissible, more people died in the US in the omicron wave than during the delta wave – there have been more than 150,000 deaths in the US since December 2021.

A third factor that some experts have suggested is involved is the waning of immunity. However, in England, different age groups were vaccinated at different times, but cases in the latest wave began rising in all age groups at the same time. This suggests that waning immunity isn't a major factor.

How bad will it get?

The severity of this second wave of omicron, in terms of deaths and hospitalisations, will depend mainly on vaccination rates. For instance, Australia reported twice as many cases during its omicron wave as the US, but despite people having no prior immunity from past infection, it had half the death rate. Around 82 per cent of people in Australia are fully vaccinated compared with 65 per cent in the US.

The situation in Hong Kong shows just how bad things can get when the BA.2 variant starts spreading in a population with little immune protection. Because Hong Kong's zero-covid policy had previously been effective, people there had no immunity from infection before the omicron wave, and only 30 per cent of those over 80 had been fully vaccinated. When omicron started spreading widely in February, many older people became severely ill, overwhelming hospitals and causing deaths to skyrocket.

The big question now is whether something similar could happen in mainland China, where vaccination rates are also low in older people, and which is struggling to contain its biggest outbreak since the pandemic first began in Wuhan. Tens of millions of people have been put under lockdowns since the start of March.

"If they do fail to continue to suppress the virus, they're in big, big trouble," says Katzourakis. "It would be a humanitarian catastrophe." While nearly 90 per cent of China's population is vaccinated, only 51 per cent of people over 80 have had two shots and just 20 per cent of this group have had a booster, said health officials in Beijing at a news briefing on 18 March.

"The outbreak in Hong Kong is a particularly profound lesson for us, an example that if the vaccination rate for the elderly is low, the rate of severe cases and deaths will be high," said Wang Hesheng at the National Health Commission in China.

What's more, China has been vaccinating people with locally made vaccines that are less effective at preventing infections than the mRNA vaccines used in many other countries. However, it appears that at least one of these – the CoronaVac vaccine made by China-based firm Sinovac – does still give fairly high protection against severe disease.

If China rapidly vaccinates far more of its oldest people, it should be able to avoid a repeat of Hong Kong even if it fails to suppress the virus, says Ben Cowling at the University of Hong Kong, who has studied the effectiveness of the CoronaVac and BioNTech/Pfizer vaccines used there.

He found that in people over 60, neither vaccine provided any protection against infection by omicron, but that two doses of CoronaVac are 65 per cent effective against severe disease, rising to 96 per cent with a booster. For Pfizer, it is 86 per cent and 97 per cent respectively.

WALDO SWIEGERS/BLOOMBERG VIA GETTY IMAGES

Health workers and students at a vaccination drive in South Africa

30%
Percentage of people over 80 fully vaccinated in Hong Kong

51%
Percentage of people over 80 fully vaccinated in China

82%
Percentage of all age groups vaccinated in Australia

What is certain is that this latest wave of coronavirus cases will subside, as all the other waves have done. Even if no other new variants evolved, there could still be a series of future waves of omicron as immunity wanes.

But there definitely will be new variants. In fact, researchers recently found a recombinant coronavirus with genetic material from both the omicron and delta lineages that arose when someone was infected by both at once. This "XD" recombinant isn't expected to be a major problem because it looks like omicron to the immune system, but recombination could create more problematic variants.

There is no guarantee that future variants will be less dangerous, says Katzourakis. It was a coincidence that omicron was less likely to cause severe disease in those infected, he says.

What's more, omicron not only largely evaded people's immune protection against infection, it also slightly evaded their immune protection against severe disease. As future variants evolve in a world where most people have immunity, we could see the rapid evolution of variants that easily evade protection against severe disease.

"The next omicron may take less time to arrive than omicron itself," says Katzourakis. "The hope is that this time is long enough that we can up our game in terms of vaccines and therapeutics."

"That's the optimistic scenario," he says. "The pessimistic one is that we give up on developing and deploying vaccines now that we think it's all over, and a variant comes along in a year's time that we're totally unprepared to deal with." ▮

Quantum physics

Black hole paradox solution?

Black holes may not destroy all information about what they were originally made from, which would solve a major puzzle first described by Stephen Hawking, finds **Leah Crane**

ONE of the biggest paradoxes in astrophysics may finally be solved. The question of what happens to information when it falls into a black hole has vexed physicists for decades, and now a group of researchers claims to have figured it out.

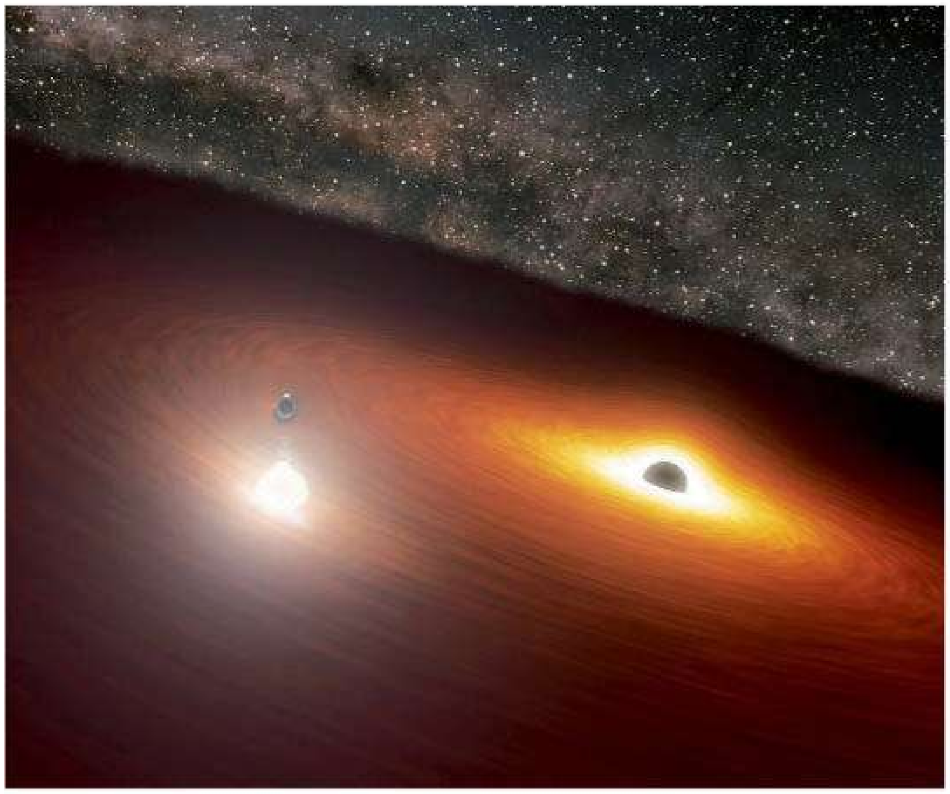
When Stephen Hawking calculated that black holes should slowly evaporate by emitting radiation – now called Hawking radiation – he also created a problem.

His work suggested the radiation should be emitted in a way that depended only on the black hole's current state and not on what previously fell into it. If correct, it would mean that when matter is pulled into a black hole, all the information about the state of that matter would be destroyed.

This isn't allowed in quantum mechanics, the laws of which require that it must be possible to use the state of any closed system at any point in time to extrapolate forward or backward in time. Essentially, it must be possible to mathematically rewind the system in order to understand its past state. However, if information is destroyed, that possibility is lost with it. This problem is called the black hole information paradox.

Xavier Calmet at the University of Sussex in the UK and Stephen Hsu at Michigan State University claim to have solved the paradox. Their work involved using a framework called quantum field theory to explore what happens when quantum mechanics and gravity interact at the edge of black holes.

When they applied quantum mechanical corrections to calculations of stars evolving into black holes, they found that these modifications required information to escape the system, along with Hawking radiation, once the star had become a black hole (*Physics Letters B*, doi.org/hmqc).


NASA/JPL-CALTECH

Artist's impression of two black holes in a distant galaxy

"If I have two black holes and they're made out of completely different things – one is made entirely out of shredded encyclopedias and the other is made of pumpkin pie – if they're the same mass, under classical physics they look exactly the same," says Hsu. "But what we're saying is that there are quantum features that distinguish between the encyclopedia black hole and the pie black hole."

> "When you put quantum mechanics into a black hole, it becomes a more mundane object"

The calculations involved comparing two stars of the same mass and radius, one of which had the same density all the way through, while the other was made of shells of different materials with different densities.

In a second paper, Calmet, Hsu and their colleagues found that these two objects look slightly different from one another if gravity is assumed to come in small packets – quanta – in the same way that other physical phenomena, such as light, do (*Physical Review Letters*, doi.org/hmqd).

Each star's collapse into a black hole isn't expected to counteract this effect, nor is the slow evaporation of the black hole via Hawking radiation, says Calmet.

"When you put quantum mechanics into a black hole, strangely enough it becomes a more mundane object and, in principle, you should be able to take everything in the evaporation process, reverse time and build back a black hole and eventually a star," he says. If this is the case, then this extra information contained in the quantum gravitational field of the black hole would solve the black hole information paradox.

However, actually measuring that quantum information is far beyond any of our current capabilities, says Hsu. That makes this theoretical solution nearly impossible to confirm observationally or experimentally.

"It's a potential way out of the black hole information problem, but it would be extraordinarily difficult to find out whether it is the actual way out of the problem," says Neil Lambert at King's College London.

Even if this quantum information were the mechanism by which the information paradox is solved, the vagueness of this solution presents its own problem, says Don Marolf at the University of California, Santa Barbara.

"The real question is, how is this information inside the black hole transferred to the outgoing radiation and where does that happen?" says Marolf. "Noting that the information is correlated to what's going on far away from the black hole doesn't actually tell you how and where that information is transferred to the radiation."

In other words, the question of how exactly information escapes from a black hole when even light remains trapped inside stays unanswered regardless of whether quantum effects allow us to differentiate between an encyclopedia black hole and a pie black hole, he says.

There is more work to be done to dig down into what these quantum corrections really mean for our understanding of black holes and gravity, says Calmet.

But this research takes us one step closer to understanding how quantum gravity works, he says – which is an even bigger mystery than the information paradox. ■

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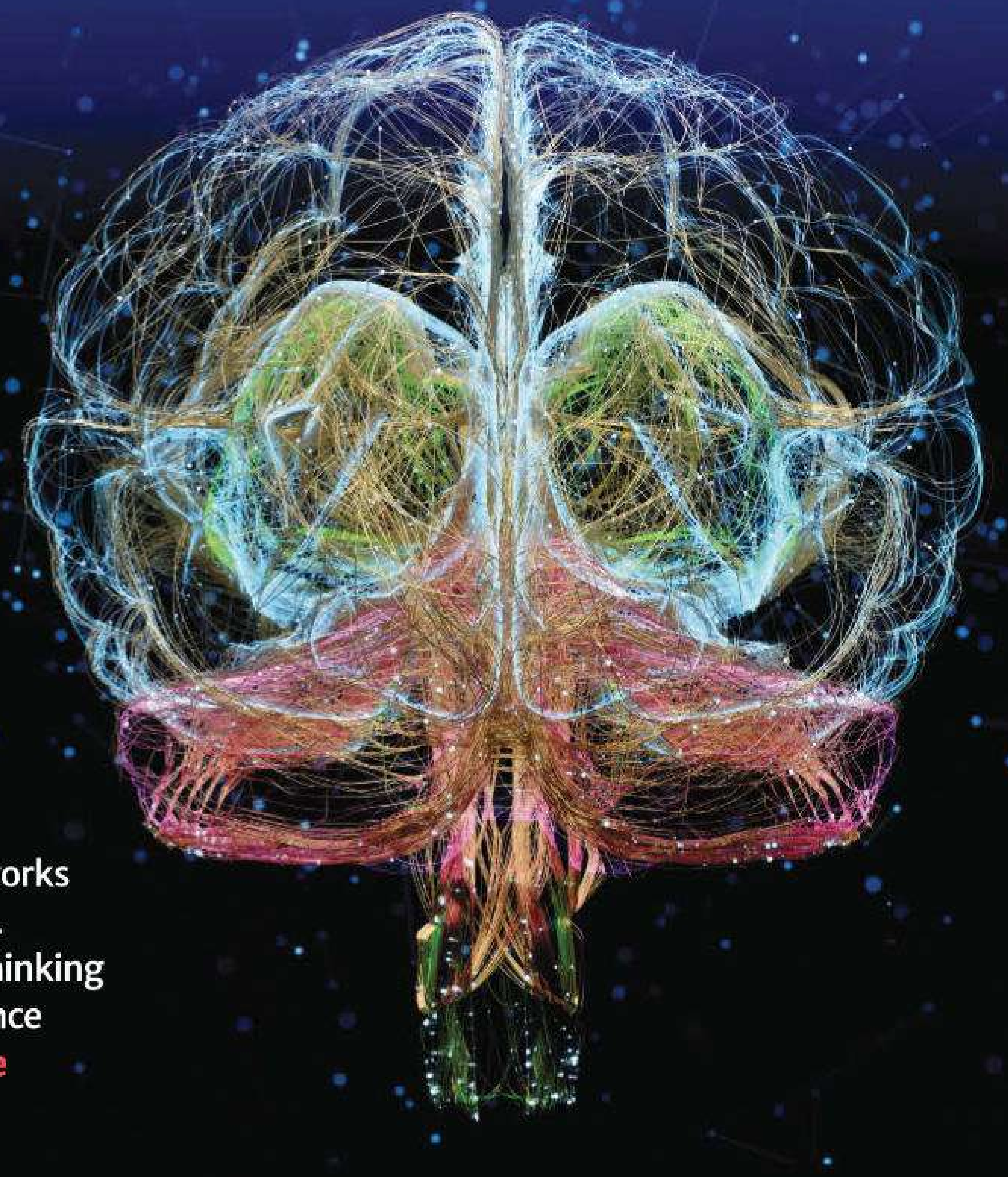

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Geophysics

Magnetic waves offer a window on Earth's core

Chen Ly

TINY magnetic waves discovered at the centre of Earth could help illuminate what is going on deep inside our planet.

Earth's core has a solid inner portion and an outer layer made of liquid metal. The difference in temperature between the two drives convection currents in the liquid, and the movement of charged particles in this metal creates the planet's magnetic field.

The motion is turbulent and chaotic, causing the magnetic field to vary over time. Nicolas Gillet at Grenoble Alpes University in France and his colleagues observed Earth's geomagnetic field between 1999 and 2021 using data from satellites as well as observatories on the ground.

The team discovered that the magnetic field around the equatorial region of the core regularly fluctuated. These fluctuations repeated every seven years, drifting westward around the equator at speeds of about 1500 kilometres per year (*PNAS*, doi.org/hmr3).

"It's fascinating that by recording the magnetic field of the Earth using satellites, we're able to image what's going on more than 3000 metres below our feet," says Gillet.

There has been a debate over whether there is a thin layer of rock sitting between the outer core and the mantle above it that may explain changes in the magnetic field, but these findings suggest that there is no need for this layer.

"This study is an exciting advance in our understanding of how Earth's magnetic field operates on timescales of less than a decade," says Chris Finlay at the Technical University of Denmark. "Much longer time series, requiring continuous observations of the geomagnetic field from space in the upcoming decades, are essential in order to fully test this new model."

Animal intelligence

Complex octopus brains may have evolved like ours did

Michael Le Page

AN ANALYSIS of genetic material in octopuses suggests that the brains of cephalopods evolved greater complexity in the same way as vertebrate brains did – by using a lot of regulatory RNAs called microRNAs (miRNAs) to control gene activity.

"We show that the major RNA innovation of soft-bodied cephalopods is a massive expansion of the miRNA gene repertoire," say the researchers, led by Nikolaus Rajewsky at the Max Delbrück Centre for Molecular Medicine, Berlin, in the paper, which is yet to be peer reviewed. "The only comparable miRNA expansions happened, strikingly, in vertebrates."

The intelligence of octopuses, squid and cuttlefish has long intrigued biologists, not least because it is so unusual among molluscs and invertebrates. Such intelligence is widely assumed to require a more complex brain, so various research groups have been looking at how cephalopod brains became complex.

Rajewsky's team found that the number of different miRNAs in cephalopods is comparable with those in vertebrates. More than 50 miRNAs arose in squid and octopus ancestors. These have been conserved since the two lineages split more than 300 million years ago (bioRxiv, doi.org/hmdv), suggesting a vital role. No other invertebrates evolved so many miRNAs.

> "The only comparable microRNA expansions happened, strikingly, in vertebrates"

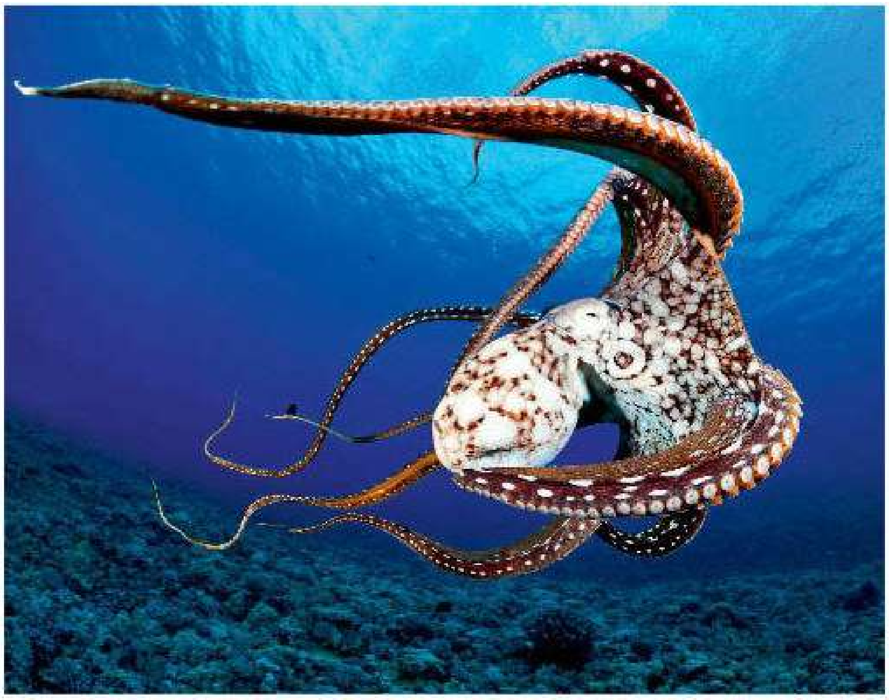
The main RNA molecules made by cells are messenger RNAs, copies of genes that carry instructions for making proteins. MicroRNAs are small pieces of RNA that don't code for proteins, but instead regulate the activities of many different genes, typically by interacting with many messenger RNAs.

Having a higher number of different miRNAs would allow cephalopods to generate more types of neurons and could thus underlie brain complexity. While the team hasn't shown this is the case, it did show that many of these miRNAs are active in the developing brains of octopus hatchlings. "We propose that miRNAs are intimately linked to the evolution of complex animal brains," state the researchers.

The authors didn't want to discuss the work prior to publication in a peer-reviewed journal, but others say it is fascinating. "We certainly agree that a dramatic expansion of the miRNA repertoire may have contributed to the development of the complex nervous system," say Joshua Rosenthal at the Marine Biological Laboratory in Massachusetts and Eli Eisenberg at Tel Aviv University in Israel. But they think it might not be the only mechanism involved.

In 2017, a team including Rosenthal and Eisenberg suggested that cephalopod brain complexity is due to a process called RNA editing, which refers to changes made to messenger RNAs that can alter genetic sequences. RNA editing happens in all complex cells, but Rosenthal and Eisenberg found that sequence alterations are especially common in cephalopods. They suggest this enables single genes to generate a wider range of different proteins, and that this is what led to greater brain complexity.

Rajewsky's team didn't find any evidence that RNA editing is especially important in octopuses. But the idea that RNA editing plays a part can't be dismissed, says Clifton Ragsdale at the University of Chicago. He says his team has found much higher levels of RNA editing in nervous systems of squid than in other tissues, in work yet to be published.



A day octopus photographed near Hawaii

DAVID FLEETHAM/ALAMY

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Astronomy

Eye in the sky is working well

The James Webb Space Telescope has sent back its clearest image yet

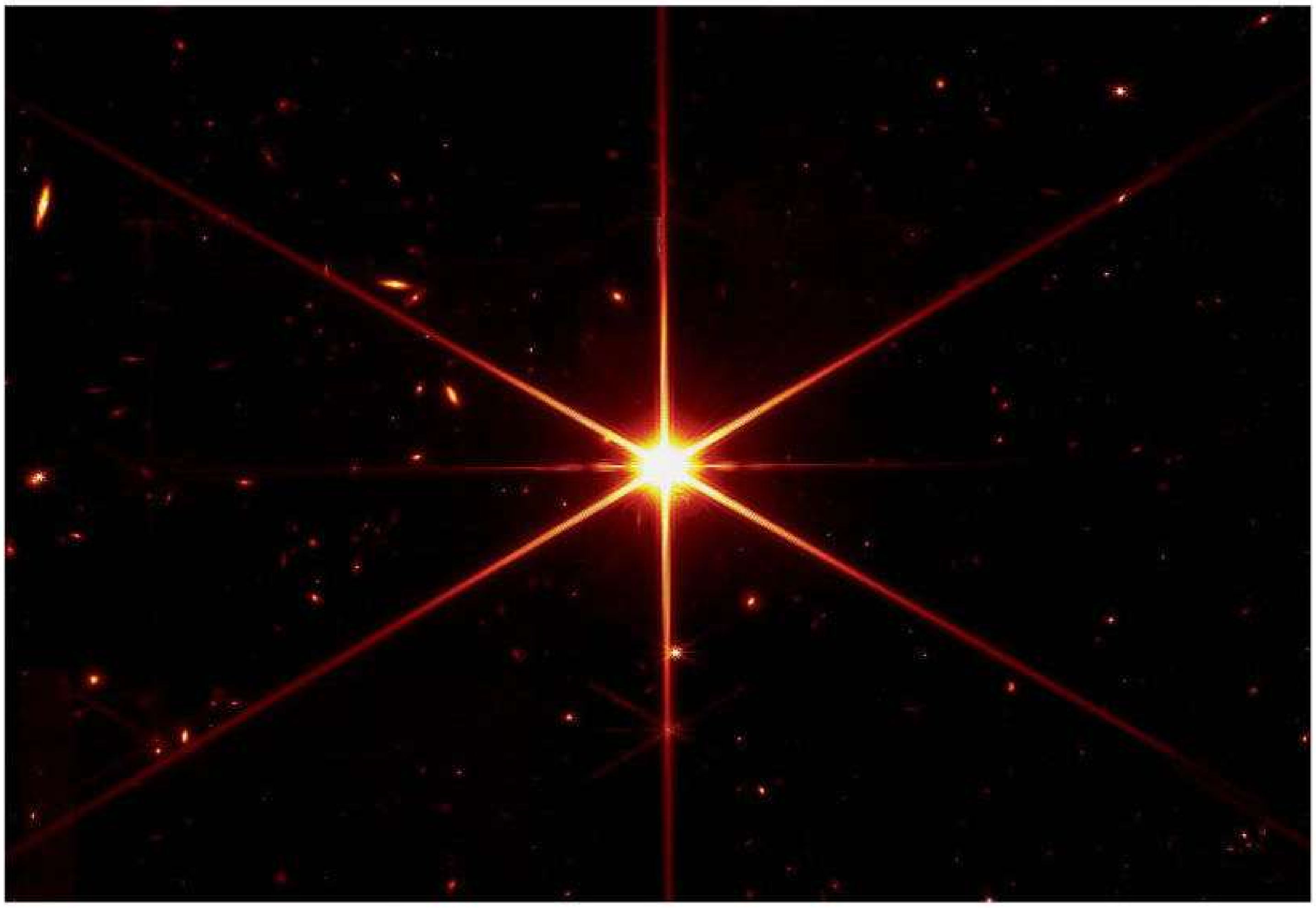
Leah Crane

THE latest pictures taken by the James Webb Space Telescope (JWST) show that everything is working even better than expected.

JWST peers into the cosmos with the help of 18 gold-plated hexagonal mirrors. For it to work properly, all of these mirrors have to be aligned with extraordinary precision – within nanometres – so that they act as one.

If the alignment hadn't been precise enough, there would be multiple copies of the bright star in this image, but it shows that the mirrors are now all working together to create a single image of a star flanked by distant galaxies. It is the highest resolution infrared image ever taken from space.

"This is as sharp an image as you can get from a telescope of this size," said JWST scientist Marshall Perrin at the Space Telescope Science Institute in Maryland during a 16 March press conference. ▮



NASA/STSCI

Genetics

Genome project will show human diversity

THE human genome is being sequenced again – but better. A project to read DNA from a large number of people has launched, with the aim of sequencing the "pangenome", a version of the genome that reflects more fully the genetic diversity of our species.

A human genome was first sequenced between 1990 and 2001. However, it was incomplete because many chunks couldn't be reconstructed. Geneticists have improved it since, with the last major update released in 2017, but large gaps remained.

In 2021, the Telomere-to-Telomere (T2T) consortium reported that it had sequenced a genome from end to end, with almost no gaps. However, it used a shortcut of sorts. Normal human cells are diploid, which means they carry two copies of the genome, which can differ. In contrast, the cells the T2T team used had two almost identical copies. This made it easier to sequence, but it also meant the genome couldn't reveal how DNA varies within a person.

The members of the Human Pangenome Reference Consortium want to do better by sequencing diploid genomes. As a first step, they asked 14 research groups to sequence the same person's genome as best they could, and received 23 attempts. They then evaluated the strengths and weaknesses of each attempt, before devising an optimised method that combined the best of all of them. The result was a high-quality diploid genome sequence with very few gaps (bioRxiv, doi.org/gpm8r5).

"It's better than the current reference [genome, published in 2017], but we also know we can do better," says Erich Jarvis at the Rockefeller University in New York.

The consortium now aims to sequence the diploid genomes of about 450 people from all around the world, which will provide a better sense not just of how DNA varies within an individual, but how it varies between individuals.

"One of the major goals is to create something that could be used for personalised medicine"

This will represent genetic diversity in a better way than the current reference has, says Kerstin Howe at the Wellcome Sanger Institute in Hinxton, UK.

"One of the major goals here is to create something that could be used for personalised medicine in the future," says Giulio Formenti, also at the Rockefeller University.

The more accurate and complete the reference sequence is, he says, the better doctors can identify variants that contribute to people's risk of disease. ▮

Michael Marshall

Psychology

Could I land a plane? Of course, I saw it on YouTube

Christa Lesté-Lasserre

PEOPLE can be so confident about their competence even if they lack relevant skills for a task – including landing a commercial aircraft – that they could put themselves and others in serious danger.

Maryanne Garry at the University of Waikato in New Zealand and her colleagues enlisted 780 volunteers in a study on this. Half of them watched a short, silent YouTube video showing two commercial pilots landing a plane.

30%

Confidence boost non-pilots had in their flying skills after viewing a video

The researchers then gave each participant a hypothetical scenario: imagine you are on a small commuter aircraft. Due to an emergency, the pilot is incapacitated and you are the only person left to land the plane.

Finally, participants were asked how confident they would feel – on a percentage scale – about responding to the situation.

People who had watched the video were up to 30 per cent more confident in their ability to land a plane without dying, compared with the confidence ratings of those who hadn't seen the video (*Royal Society Open Science*, doi.org/hmcz).

But even the participants who hadn't watched the video gave themselves an average confidence score of 29 per cent for their ability to land, says Garry.

Garry says the findings suggest that people "tend to inflate their confidence about certain things" as a result of what she calls a rapid illusion, meaning they see images that make them believe they are capable of feats for which they have no skill. The results suggest this applies to a "disturbing proportion of ordinary people", she says. ▮

Analysis Neuroscience

Doubts cast on brain scanning research

Most studies are too small to make reliable conclusions about the neural basis for complex traits, says **Clare Wilson**

BRAIN scanning studies that use magnetic resonance imaging (MRI) machines are often said to show links between the brain's structure or patterns of activity and complex traits, such as depression, autism and certain aspects of personality. But for years, there have been suspicions that some of the headline-grabbing results aren't trustworthy. Now, that has been confirmed.

Almost all such work so far has had too few participants to find reliable results, according to research by Scott Marek at Washington University in St Louis, Missouri, and his colleagues. His group found that such studies need to look at the brains of thousands of people; they usually each include an average of about 23 individuals.

Marek and his team analysed results from three of the largest ongoing neuroimaging studies to date, including the UK Biobank study, which had scanned nearly 36,000 participants at the time. They looked at links between brain structure or functioning and two relatively well-studied traits: cognitive ability and, in children, scores on a checklist for "psychopathology", a combination of several behavioural measures.

By doing multiple analyses with varying numbers of people, they showed that when small sample sizes were used, they could find apparent correlations between these traits and the brain's structure or function. But analyses of larger groups showed that these effects were either exaggerated or completely spurious. In some cases, different small samples could reach opposite conclusions, simply because people's brains are so variable that random chance can sway the results one way or another (*Nature*, doi.org/gpps4r).

Although Marek's team only looked at two traits, it is likely that its conclusion that these kinds of brain scanning studies need thousands of participants is true more broadly, says Kevin Mitchell at Trinity College Dublin in Ireland.

There is no reason to think that complex intellectual traits like people's appetite for risk-taking or their political leanings will necessarily have any manifestation in brain tissues that would be visible on a scan, says Mitchell.

Results from previous small brain scanning studies of this type should now be viewed with suspicion – and unless it contains thousands of participants, the same goes for ongoing research.

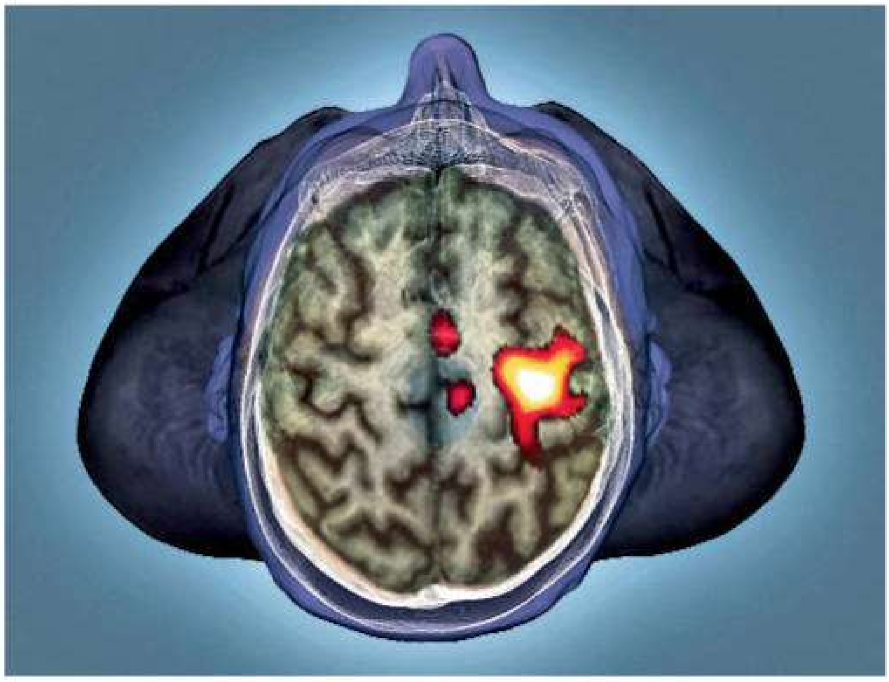
The new analysis may lead to the MRI field having a kind of existential crisis, says Cassandra Gould van Praag at the University of Oxford. "There's a bit of *The Emperor's New Clothes* about this."

There are parallels here with research into the genetics of mental health. In the 1990s, there were similar eye-catching claims that researchers had found the genes "for" things like depression and aggression, based on small studies with tens or hundreds of participants. Then, larger studies that sequenced all the DNA of several hundred thousand people at a time showed that common conditions like depression are actually influenced by hundreds of gene variants that each have tiny effects.

None of the results from small studies on the genetics behind mental health was borne out. They probably found false results because of a failure to use good research practices, like preregistering the study's methods before collecting and analysing the data, as well as checking the results in a second group of people before making any claims, says Mitchell.

The field of brain scanning needs a similar overhaul, with researchers committing to proper research practices before they get funding in future. Existing small studies could still be salvaged if multiple research teams band together to produce one large study, says Marek. ▮

A functional MRI scan showing activity in the brain's motor cortex



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The UK's nuclear waste and the geological solution

The best way to deal with Britain's radioactive waste is to bury it deep underground, says the government and scientific community. *New Scientist* asked a panel of experts to discuss the scientific, engineering and social challenges ahead.

The UK has produced radioactive waste since the dawn of the nuclear age some 70 years ago. The waste comes from nuclear power stations, medical and industrial facilities and the defence programme. Some of the higher activity waste will take tens of thousands of years to decay and is currently stored above ground in around 20 secure facilities, which cost billions of pounds to maintain. Within the next 100 years, the total amount is expected to fill a volume of almost 250,000 cubic metres – around three times the size of the Royal Albert Hall.

"There has been a lot of consideration about what to do with the waste," says Cherry Tweed, a materials scientist and chief scientist for geological disposal at Nuclear Waste Services, the government organisation charged with disposing of the waste.

In the early 2000s, the UK government set out to find the solution and agreed on disposing of the material in a geological disposal facility (GDF). There is international consensus here – other facilities have already been built in the US, and construction of another is underway in Finland. Plans are also afoot in France, Sweden, Switzerland and Canada.

The facility would be designed to securely lock away the waste, protecting future generations against any radiation hazard and freeing them from the commitment to deal with it themselves. A key part of the plan is to find a community willing to host this facility and several in Cumbria and Lincolnshire are currently discussing the possibility.

This approach raises numerous questions and *New Scientist* recently assembled a panel of experts to discuss these points in an online debate. At issue was the science behind a GDF, how we can be sure the material will be safe and what it means for a community to be willing to host such a facility.

"Community trust in the nuclear operators is vital"

Posiva

A key part of this process is building trust between nuclear operators and local people. Here the UK can learn from the Finnish experience, where a GDF is currently under construction in Olkiluoto, in Eurajoki, western Finland, home to one of the country's two nuclear power plants. The facility is being built 400 metres underground and waste disposal is set to begin by 2025.

Community trust in the nuclear operators is vital, said Vesa Lakaniemi, mayor of Eurajoki and one of the invited panellists. The region has hosted a nuclear power plant for over 40 years and the operator has been open and communicative with locals over that time, he said. "I can truly say that in this area people know much more about nuclear systems than for example in the eastern part of Finland," he said. Trust follows from this kind of ongoing communication, added Lakaniemi. "That trust has developed over four decades."

Operators in the UK may find developing this trust more of a challenge, said Penny Harvey, professor of social anthropology at The University of Manchester and a member of the Committee on Radioactive Waste Management which advises the UK government. "Unlike Finland, in Britain we don't have such a great history to draw on," she said. "There's been much more distrust possibly of these kinds of processes."

An important part of building trust will be demonstrating the safety of the proposed GDF. The facility will receive higher activity radioactive waste, which makes up around

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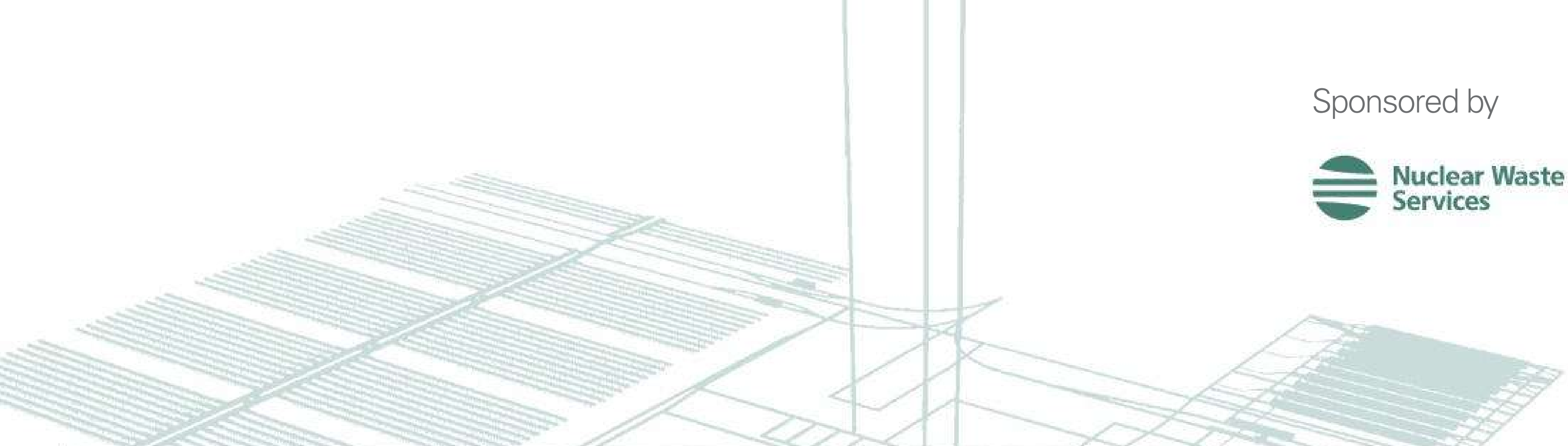

The expert panel for the *New Scientist* debate (left to right):

Professor Kath Morris
BNFL Research Chair,
University of Manchester

Vesa Lakaniemi
Mayor of Eurajoki, Finland

Professor Penny Harvey
Professor of Social Anthropology,
University of Manchester

Professor Cherry Tweed
Chief Scientist for Geological
Disposal, Nuclear Waste Services

A geological disposal facility is under construction at a nuclear power plant in Olkiluoto, western Finland

six per cent of nuclear waste in the UK. To prepare it for disposal, this waste is encased in a solid glassy or cement-like material. This will be put in a metal container and encased with a clay-like material.

"Finally, there is the geology that the geological disposal facility will be placed in, which also has a function in the safety of the overall facility," said Kath Morris, professor at the Dalton Nuclear Institute at The University of Manchester, and director of the research support office at Nuclear Waste Services. "It's the Russian Doll idea of multiple packages."

Of course, there is always the potential for accidents. In 2014, a geological disposal facility in New Mexico in the US experienced a radiation leak when a container ruptured. Although the US Environmental Protection Agency concluded that the leak did not pose a concern to public health, 21 people tested positive for low-level internal contamination. "Had that accident happened on the surface, the consequences would have been significantly more serious," said Tweed.

"We've done a lot of study to see what we can learn from it. Mistakes were made; some of the checks that should have been in place weren't followed through at the time." But the fact that the incident occurred over 600 metres underground limited the damage, she added.

Regulation and secure, long-term funding of the facility will be vital for safety, said Harvey. "An unanticipated event is almost inevitable, but as long as you've got strong regulation and government support, then it should be possible to respond appropriately and in time," she added.

Weighing up the risks and benefits of a GDF will be an important part of any discussion with local communities considering hosting a GDF. Any facility built will need to somehow make life better for local residents and enable the area to prosper, said Harvey.

But we also need to consider future generations. "What would it mean for us to take a decision that's responsible and ethical for people coming in the future?" she asked. "What would it mean for us to become good ancestors?"

Morris believes that "leaving this material is not the right thing to do." A GDF presents a way of dealing with radioactive waste – both for communities now and for future generations, she concluded. "I think the journey we're on is the right journey."

LOOKING TO THE FUTURE

If highly radioactive waste is buried underground for thousands of years, what will happen to it?

Scientists can make predictions by studying ancient natural phenomena. "There are many natural systems that have some similarities to part of the engineered barriers in a geological disposal facility," said Cherry Tweed, materials scientist and chief scientist for geological disposal at Nuclear Waste Services. Researchers have examined glasses formed by volcanoes, which bear some resemblance to the glasses that are used to encase high level radioactive waste. Tweed herself has studied naturally-occurring cement in Jordan that had water flowing through it for thousands of years. "We can start to build a good picture of how a GDF could evolve in the future," she said.

Earth's climate could also look very different in thousands of years. She said nuclear waste disposed of underground will be more protected from sea level rises than waste stored on the surface.

Future generations may develop technologies to safely degrade or dispose of nuclear waste. But that doesn't mean disposal facilities built now should make waste retrievable, said Penny Harvey at the University of Manchester. The most responsible thing the UK can do now is to bury it and "put the plug in", she said.

For more about Nuclear Waste Services, visit: https://tinyurl.com/2p8532ef

Energy

The first global energy crisis

The war in Ukraine has sent many nations scrambling for energy security. **Adam Vaughan** asks what it will look like

JESSICA RINALDI/THE BOSTON GLOBE VIA GETTY IMAGES

A protest in Boston, US, on 6 March highlighted the issue of Russian oil

IN JUST over a month, Russia's invasion of Ukraine has displaced millions of people and killed thousands on both sides. At the same time, the war has triggered historic shifts in the world of energy. Many countries have long depended on oil and gas from Russia, which is one of the world's top exporters of fossil fuels. But with those exports now politically toxic, they are scrambling to find other ways to meet their energy needs.

The European Union has committed to cutting imports of Russian gas by two-thirds by the end the year. Frans Timmermans, first vice-president of the European Commission, has said it would be hard but possible.

The world's energy systems have been going through a slow transition to lower-carbon fuels for decades. But the war in Ukraine has changed everything and energy security is now the most pressing priority. A crucial question is how this will play out for the environment. Will it mean a renewed race towards renewables, or a rush to exploit domestic fossil fuels and new suppliers of oil and gas?

Even before the war, the world had energy problems. Gas production outages and increased demand from the post-covid-19 economic bounceback saw oil and gas prices rising fast by last September. The shocks were felt around the world. In the UK, some petrol stations ran out of fuel in October and electricity prices quadrupled in 2021.

The pandemic itself had also provided an opportunity for changes to our energy systems. As many cars remained parked and planes grounded in 2020, global carbon emissions fell steeply. There was plenty of talk about building on this with a "green recovery", by injecting government funds into green technology and jobs. But this opportunity has been missed. Only 6 per cent of the $860 billion of global stimulus designed to kick-start economies was funnelled into emissions-cutting measures.

Better news came when nearly 200 countries at the COP26 climate summit in November 2021 promised to "phase down" coal, a first for the UN climate talks. But so far that hasn't happened. High gas prices meant coal-burning in 2021 reached its highest level ever. This has seen emissions jump to above where they were before the pandemic.

"Even before the war in Ukraine, the world was facing an energy crisis"

This was the backdrop as Russia invaded Ukraine in February. Events moved fast. Germany has shelved a major new gas pipeline from Russia. Along with the EU measures, the UK and US announced plans to end imports of Russian oil and gas. Many energy companies also chose to "self-sanction": Shell apologised and ceased sourcing oil from Russia after criticism for buying a shipment of Russian crude.

"In my view, it is the first global energy crisis," says Fatih Birol, the executive director of the International Energy Agency. "It will be a turning point by any means. The question is, in which direction are we going to turn?"

He sees two possibilities. On the one hand, he says, climate change is already "sliding down the policy agenda in many governments". On the other, countries could repeat the energy innovation that came out of the 1970s oil price shocks, with increased energy efficiency, more nuclear power and an increase in spending on low-carbon technologies.

To see which way things might go, a good starting point is the EU's new energy strategy, released on 8 March. It doubles down on energy efficiency, wind and solar power, with more ambition than under the existing climate plan, and it includes those cuts to Russian gas. But most of that gas will simply be swapped for gas from elsewhere, sourced through pipelines from Africa and shipments of liquefied natural gas (LNG) from countries such as the US. The EU isn't ditching gas, it is just diversifying its sources.

Other emergency responses to the crisis may also be bad news for emissions. Coal is a particular danger because it is incredibly dirty but now cheaper than gas. The UK government is reportedly

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talking to energy firms about postponing the planned closure of coal-fired power plants.

Dash for gas

In Asia, many nations have been lowering their emissions by switching from coal to gas, a cleaner if still problematic fuel. But Europe is now looking for more shipments of LNG, prices are going up and those Asian countries will end up burning more coal, says Jason Bordoff at Columbia University in New York. That is important, because Asia has been driving the majority of global emissions growth recently.

The trouble is that the US, UK and countries in the EU need a solution to this energy crisis fast, certainly before the return of their winter at the end of 2022. Dependence on gas can be reduced by switching to heat pumps, insulating houses and building more wind farms, but that takes time.

In the short term, countries are considering whether to increase domestic production of oil and gas to help curb price rises. UK prime minister Boris Johnson has recently met with energy firms to talk about boosting investment in oil and gas projects in the North Sea and how the UK government can speed up extraction.

Indeed, many people see a distinction between the short and long-term implications of this energy crisis. Chris Stark, head of the Climate Change Committee that advises Johnson, says this moment holds the potential to "get people more sharply focused on our dependence on fossil fuels", which would be good in the long run. "But the biggest concern is that we run the risk of locking in fossil fuel use, fossil fuel production especially, and actually blowing entirely the budget for [the] Paris [Agreement]."

70

Amount of hydrogen, in millions of tonnes, produced globally each year

15

Amount of extra hydrogen, in millions of tonnes, the EU wants to produce per year under its new energy security plans

Further into the future, things may be brighter. "In the long term, the energy security agenda aligns very well with the decarbonisation agenda," says Thijs Van de Graaf at Ghent University in Belgium. Adair Turner, chair of the Energy Transitions Commission, an international group funded by major energy companies, says that insulation, heat pumps and wind farms will all see more investment over the next five years because of today's crisis.

One practical step the UK and EU are exploring is how to remove planning system hurdles for renewables projects. Birol hopes there will be major leaps in energy efficiency, renewables, electric cars, hydrogen and small modular nuclear reactors. "There's no reason it cannot happen," he says.

Hydrogen and nuclear power are two technologies that can help decarbonise the energy sector and provide greener power for heavy industry. Will these help fend off energy woes?

When produced in the right way, hydrogen is a relatively clean fuel and it is a key part of the EU's plan for weaning itself off Russian gas. An extra 15 million tonnes of renewable hydrogen per year is planned by 2030, 10 million imported and 5 million made in Europe.

That is huge, and possibly unrealistic. Renewable hydrogen production today is minuscule. Only 70 million tonnes of hydrogen are produced globally per year and almost all of this is made from fossil fuels through a process called steam reformation, which releases carbon dioxide. "I am missing the implementation, the policies that are going to make that possible," says Anne-Sophie Corbeau at Columbia University.

It will also be expensive, and it is unclear how imports will be transported, she says. The EU's strategy had embraced hydrogen produced through gas-powered steam reformation and the clean process of making hydrogen from water using electrolysis. But Corbeau thinks high gas prices mean the strategy will now evolve to favour the latter.

"This crisis will be a turning point. The question is: which direction are we going to turn?"

Under pressure to switch to cleaner fuels, Russia had been planning a pivot to supply Europe with hydrogen in future. But another implication of the war, says Corbeau, is that this idea has had a "first-class funeral".

What this crisis means for nuclear power is less clear. Nuclear plants in Europe are ailing. A new plant in Finland is nearing full output, but it is 13 years behind schedule. France has a large fleet of nuclear power stations, but they are ageing and output forecasts have been revised down this year due to some reactors being offline. It is a mixed picture elsewhere, ›

A worker repairs an oil pipeline owned by Russian firm Gazprom

ANDREY RUDAKOV/BLOOMBERG VIA GETTY IMAGES

too. Belgium is weighing whether to postpone planned closures of its nuclear power stations. But Germany has ruled out delaying its scheduled nuclear exit at the end of the year.

Stark says extending the life of nuclear plants makes sense, if they are safe. "Globally, definitely we should be looking again at plans to close nuclear power stations early." UK prime minister Johnson has called for a "lot more nuclear", suggesting that proposals for a new plant in the east of England could get the go ahead.

"Politicians are talking more in the language of energy self-sufficiency"

Politicians are also talking more in the language of energy self-sufficiency. Germany's finance minister, Christian Lindner, has called renewables "the energy of freedom". Johnson recently said "now is the time to unleash an extraordinary programme of energy independence".

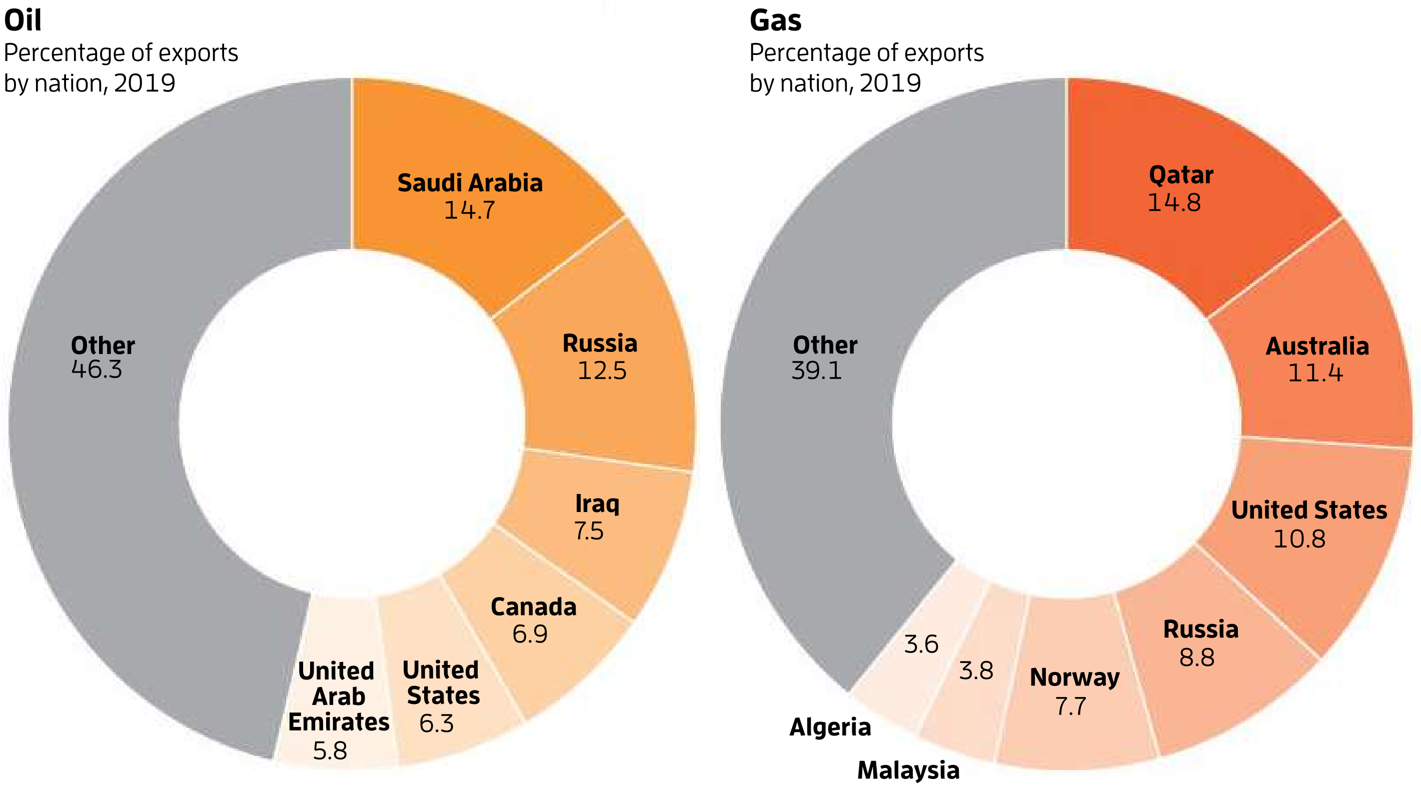
Would energy independence be a good thing? It might seem like an attractive idea, with nations shielded from the impacts of world events. But it isn't so simple.

For starters, true energy self-sufficiency is impossible. "Energy independence never worked. The idea that you can isolate yourself from shocks is wishful thinking," says Bassam Fattouh at the Oxford Institute for Energy Studies.

Russia is a major producer of oil and gas, but it is far from the only one (see charts, above). The UK sources only about 4 per cent of its gas from Russia. The price of gas is set internationally, however, and gas is still a bedrock of UK electricity generation and heats most UK homes, so the UK is still exposed to the shock: a typical annual energy bill is projected to reach nearly £3000 from October.

The oil and gas giants

A few nations dominate the export of oil and gas, and Russia is a big player in both industries



SOURCE: OBSERVATORY OF ECONOMIC COMPLEXITY

£3000

The projected annual price of a typical UK household energy bill by October 2022

Even for big energy-producing countries like the US, the idea that they could become energy islands is a fantasy, says Bordoff. Some in the US have argued that the country should detach from international markets to keep US oil and gas cheap, but he says that would reduce resilience, removing the safety net of imports when hurricanes hit the Gulf of Mexico and halt domestic oil production.

Connection not isolation

"Energy security comes not from being disconnected and isolated, but actually from more interconnection and integration," says Bordoff. Ottmar Edenhofer at the Potsdam Institute for Climate Impact Research in Germany agrees: "Energy security means diversification of imports, not necessarily less imports."

That said, today's energy crisis will probably fuel deglobalisation, with supply chains and manufacturing kept within borders, a trend that had been boosted already by the pandemic. "We have had these two accelerating moments now, all pointing to the same direction," says Van de Graaf. Even pre-covid-19, European countries had taken steps to encourage battery factories to set up within their borders, to reduce manufacturers' reliance on Asian battery plants.

The issue could soon get more complex. Batteries contain a witches' brew of chemical elements sourced from around the world. Russia itself is a major producer of nickel, an important ingredient in lithium-ion batteries. "The supply chain resilience conversation was already on the go because of the pandemic, but this will just amp it up to 11," says Jeff Colgan at Brown

The energy crisis of the 1970s led to shortages at the petrol pumps

OWEN FRANKEN/CORBIS VIA GETTY IMAGES

University in Providence, Rhode Island. Of course, it isn't just energy that is affected by supply chain issues (see "The price of bread", below).

In a few years, we might be living in a world where new clubs of nations have formed, with fresh links between countries on the basis of sharing renewable energy, for example. "The supply of sunshine and wind is not evenly distributed across the world, but it's much more evenly distributed than fossil fuels," says Turner.

He envisages a significant amount of international trade even after oil and gas use comes down. High-voltage, long-distance electricity cables linking renewable energy projects in Morocco to the UK, and Australia to Singapore, are already being planned. Connections like these could smooth the variable nature of wind and solar power. "In a logical, peaceable world, we'd be linking up grids all over the place," says Turner. "I think that will occur and should occur."

The 1970s oil shock prompted a massive rise in public spending on research and development in energy. Nuclear, hydrogen, solar power and fuel efficiency in cars all benefited. Will history repeat? "I think the answer is probably yes," says Bordoff.

Corbeau thinks the focus will be on technologies that are essential for decarbonisation – such as carbon capture and storage and hydrogen – and how to scale them up. Yet she is sceptical that governments, with public finances stretched by covid-19 and financially insulating consumers from energy prices, will have the resources for it.

One route in the UK is the "high-risk, high-reward" Advanced Research & Invention Agency, which starts in May with an £800 million budget to 2024.

Turner says research into energy storage will be crucial. There are times when it isn't windy or sunny for days or weeks on end. Batteries can't help in such cases, because they don't have enough capacity to last that long at scale.

So if countries are to become more self-sufficient, and use low-carbon energy, they will need new forms of long-duration power storage. That will mean investing in existing technologies such as pumped hydro, which involves pumping fluids uphill, storing them there, and then letting them flow downwards to turn a turbine and generate power when needed. It may also involve more embryonic forms of storage, such as compressed air.

"The tools we need to decarbonise our energy systems can also provide energy security"

In another shift towards independence, Bordoff thinks research spending will increasingly be aligned with countries' industrial strategies, so that jobs and supply chains are within their borders. Denmark's push to jump from being an oil exporter to cementing its lead in wind power is one such example.

Most observers think it is too early to say which direction the world will take from the current energy crossroads, but they largely agree on two things.

First, the tools we need to decarbonise our energy systems can also deliver energy security. And second, the importance of energy security will be elevated for a long time, after two decades of low prices and abundant supplies of energy in Europe and the US. "Suddenly, people have realised energy security is not something that could be forgotten," says Corbeau.

The price of bread

Food prices were at record highs even before Russia's invasion of Ukraine and the war is likely to push them up even further. The UN's food price index was at an all-time high of 140.7 points in February, beating the previous record from 2011. Back then, a food price crisis sparked riots across the Middle East and south Asia.

The reasons the war is making food prices spike are twofold. The first is supply. Russia and Ukraine together export about 30 per cent of the world's wheat, more than half its sunflower oil, and Russia is also a major producer of fertilisers. Just as Russia's oil and gas are no longer deemed viable imports for Western nations (see main story), so supply of foods is being affected too.

The second factor driving up food prices is a global one. Gas and oil prices are soaring everywhere as a result of the war and this also hits farming.

Farm machinery needs fuel to keep running. And making fertiliser is an energy-intensive process, involving a high-pressure chemical reaction called the Haber process. Earlier in March, Norwegian fertiliser company Yara temporarily curbed production in France and Italy due to high gas prices.

The impacts of rising prices will be felt unevenly across the globe, with lower-income countries and communities hit hardest. Iraq has already seen protests erupt in early March over food prices. Hungary banned exports of grains on 4 March over food security concerns. Ronald Kers of 2 Sisters, a major UK food manufacturer, has said consumers in the country should expect food price rises of up to 15 per cent this year.

ALL CANADA PHOTOS/ALAMY

Animal behaviour

Our mixed messages can put wildlife in peril

WELL-MEANING people might be putting wild animals in danger by being kind and generous, in a world where not all of us act this way.

Wildlife can quickly learn whether humans are trustworthy. But different people act differently, and "mixed messages" put animals at risk, says Madeleine Goumas at the University of Exeter, UK.

Unlike other animals – especially predators – we show very different individual behaviours towards other species, says Goumas. Some people ignore or avoid wild animals; others approach, feed or pet them; others pursue, capture, harm or hunt them. This makes it complex for animals to know how to act around us.

Goumas and her colleagues have developed a computer model to assess how wild animals cope with the mixed messages we send out. It suggests animals that learn rapidly whether to trust humans are better able to survive in places where people generally act in the same way, either friendly or hostile, says Goumas. In the real world this means, for example, that deer can take advantage of grazing grounds in urban areas, where people leave them alone or are even friendly to them. Meanwhile, deer in woodland popular with hunters can survive better by quickly learning to hide.

However, the model also suggests that fast learning in places where there are varied attitudes towards wild animals can be detrimental, says Goumas. Simulated animals in these places quickly made conclusions about all humans based on a single good or bad experience (*Royal Society Open Science*, doi.org/hmcr). **Christa Leste-Lasserre**

Global warming

Climate change may worsen hay fever

POLLEN season may start up to 40 days earlier and get more intense in the US if temperatures rise this century as predicted in some climate change scenarios.

Yingxiao Zhang at the University of Michigan and her colleagues wanted to find out what pollen season will look like at the end of the century. They combined climate models with data taken between 1995 and 2014 from sites across the US for levels of 13 of the most common types of pollen in order to predict levels between 1981 and 2100.

They found that plants would start releasing pollen up to 40 days earlier if temperatures in the US rose between 4 and 6°C. They also found that plants that pollinate later in the year may do so up to 19 days later – lengthening pollen season and increasing annual pollen emissions across the US by between 16 and 40 per cent.

Factors other than temperature would have an effect too: rising carbon dioxide levels could have the biggest impact on pollen. Based on findings from previous lab studies, the researchers found that the predicted atmospheric CO_2 increase this century may raise pollen emissions across the US by up to 250 per cent (*Nature Communications*, doi.org/hmc2).

The researchers say that CO_2 may have such a big effect because of its major role in photosynthesis. "More carbon dioxide may mean plants grow bigger and stronger and this would impact the release of pollen," says Zhang. But she says there is uncertainty in that result due to a lack of data on CO_2 effects.

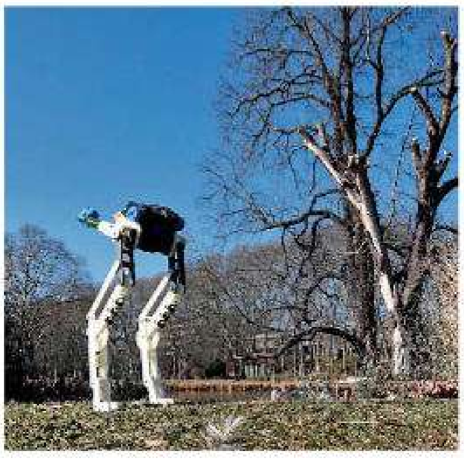
"For nearly all children with asthma, more pollen means greater chances they'll have an asthma attack," says Aaron Bernstein at Harvard University. "So we can hope that this study got it wrong, but odds are it didn't." **Jason Arunn Murugesu**

Technology

Bot that trots like an emu is extra efficient

A PAIR of robotic legs with an unconventional design inspired by emus can run 300 per cent more efficiently than a traditional version. The technology could be used in prostheses and exoskeletons, say its inventors.

Alexander Badri-Spröwitz at the Max Planck Institute for Intelligent Systems in Stuttgart, Germany, and his colleagues have done away with the usual approach where every joint in a robotic limb has one actuator to open it and one to contract it. Instead, their BirdBot uses just two motors in each leg combined with long artificial tendons that cover more than one joint, mimicking the anatomy of certain birds that have lost the ability to fly.



DLG MPI-IS & UC IRVINE

The motors pull the tendons. Power is stored in a spring during compression and released when each foot strikes the floor, to help drive the robot forward. The BirdBot managed a top speed of 75 centimetres per second in tests on a treadmill (*Science Robotics*, doi.org/hmcx). Guides are still required to keep the robot running straight and true, but the focus of the research was efficiency, not balance, says Badri-Spröwitz.

Shival Dubey, who is at the University of Leeds in the UK, says the design is more efficient than more complex devices, but may also be less adaptable when it comes to carrying loads of varying weight. **Matthew Sparkes**

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Really brief

SAEED KHAN/AFP VIA GETTY IMAGES

Australian wildfires harmed ozone layer

The bushfires that devastated Australia in 2019 and 2020 sent smoke so high it reached the stratosphere where it sparked the formation of ozone-destroying chemicals. This led to a 13 per cent decline in ozone over parts of the southern hemisphere, but the effect was temporary (*Science*, doi.org/hmbm).

Climate sensors scatter on wind

Tiny devices with a design inspired by dandelion seeds can be carried on a breeze and spread through an environment. The sensors, which track factors such as temperature, offer a way of monitoring fine-scale variation in conditions across an area of interest (*Nature*, doi.org/hmcn).

Tiny worms can detect lung cancer

Microscopic nematode worms can tell healthy and cancerous human lung cells apart. They crawl towards the cancer cells, which have a similar scent to the worm's food, and could one day form part of a system to detect this illness, a team reported at an American Chemical Society meeting this week.

Astronomy

Asteroid spotted just before it struck Earth

A SMALL asteroid harmlessly collided with Earth on 11 March, exploding over the Arctic just hours after astronomers first detected it.

The space rock, named 2022 EB5, was first detected at 7.20pm GMT at Piszkéstető Station Observatory in Hungary by astronomer Krisztián Sárneczky. Other astronomers were then able to track it before it plunged through the skies to the north-east of Iceland just after 9.20pm GMT. It is one of only five asteroids to have been spotted and observed before hitting Earth.

Thankfully, the object was sufficiently small that it posed little danger – early estimates suggest it was around 1 to 2 metres across. "Impacts of this size can be considered completely harmless. They typically create so-called 'airbursts' at altitudes of about 40 kilometres above ground," says Richard Moissl at the European Space Agency's Planetary Defence Office.

A signature of the disintegrating asteroid was picked up by infrasound monitoring stations that listen out for pressure waves from nuclear weapons tests.

Peter Brown at Western University in Ontario, Canada, who is an expert at interpreting such data, tweeted that the energy released by the detonating space rock could have been equivalent to around 2 kilotons of TNT.

Moissl says events like these allow astronomers to make measurements that can shed light on the characteristics of an asteroid, such as its density or composition. **Will Gator**

Drugs

TED KINSMAN/SCIENCE PHOTO LIBRARY

AI scours psychedelic trip reports for medical clues

ARTIFICIAL intelligence has been used to analyse people's accounts of experiences with psychoactive drugs to gain a better understanding of how they work in the brain.

Psychedelics such as LSD and psilocybin – the active compound in magic mushrooms (spores of which are pictured) – could be used to treat conditions including depression. The experiences they induce, which may be important for therapeutic effects, are varied, and can include visual and auditory hallucinations and an altered sense of self.

Danilo Bzdok at McGill University in Montreal, Canada, and his colleagues used a pattern-recognition algorithm to scour 6850 accounts of experiences submitted on the website Erowid, involving 27 different drugs.

They linked words used in the accounts for each drug, such as "euphoria", "nausea" or "visuals", with any of 40 receptors in the brain that the drug is known to interact with, and mapped these effects onto areas of the brain where these receptors are most active (*Science Advances*, doi.org/gppw7s).

The team hopes the work will help identify drugs that may induce particular subjective effects, and provide a framework for developing new treatments. **MS**

Optics

Bionic eye has 'pupil' that responds to light

AN ARTIFICIAL eye that mimics the widening and shrinking of the pupil may bring us a step closer to helping people with certain visual impairments.

Light enters the eye via the pupil before hitting the retina. This converts the light stimuli into nerve impulses, which travel to the brain via the optic nerve.

The so-called pupillary light reflex compensates for changes in light levels by adjusting the pupil's size. This allows us to see in high resolution and protects the retina from bright light, but the process can be impaired if the optic nerve or oculomotor nerve is injured.

Xu Wentao at Nankai University in China and his team have now developed a material that mimics the pupillary light reflex in an artificial eye model. It is based on the mineral perovskite, known to act as an artificial synapse. A synapse is a gap between neurons through which nerve signals pass.

Xu's team added a thin layer of the material and an alloy fibre to an artificial eye. When exposed to light, the material sent neural-like signals to the fibre, which then controlled the pupil (*Matter*, doi.org/hmc8). The next step is to develop an artificial eye that perceives colour, says Xu. **JAM**

New Scientist
Events

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CLAUDIA DE RHAM

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Views

The columnist
Graham Lawton on the Ukraine war's green impact p28

Aperture
Vibrant rainbow-coloured fish named as a new species p30

Letters
We need to choose carbon capture tree species carefully p32

Culture
A true-crime series about an intriguing insect heist p34

Culture
The life and death of a pair of volcanologists and film-makers p36

Comment

History's unsung heroes

The idea that modern science is a European invention ignores key global contributors. We need to acknowledge them, says **James Poskett**

SIMONE ROTELLA

WE ARE usually told that modern science was invented in Europe sometime between 1500 and 1700. This was an era in which a small group of European pioneers overturned ancient superstition and developed the first modern scientific theories. Think of Polish astronomer Nicolaus Copernicus and his heliocentric model of the universe or English mathematician Isaac Newton and his law of universal gravitation. This was the scientific revolution and it set the stage for what was to come: Europe continued to make incredible advances, leaving much of the rest of the world to catch up.

You are probably familiar with this story. It features in almost every popular account of the history of science. There is, though, one big problem with the idea that modern science was invented in Europe: it just simply isn't true.

Over the past decade, historians have pieced together a very different account of the origin of modern science. It wasn't a product of a unique European culture. Rather, it depended upon a global cultural exchange.

We now know that many of the pioneers of modern science in Europe relied on theories and observations borrowed from elsewhere. In his 1543 book *On the Revolutions of the Heavenly Spheres*, Copernicus cited no less than five Muslim scientific writers, including the Syrian mathematician Thabit ibn Qurra and the Iberian astronomer Nur ad-Din al-Bitruji. Most importantly, Copernicus made use of a mathematical technique first developed by the Persian astronomer Nasir al-Din al-Tusi. Known as the Tusi couple, this allowed Copernicus to model the oscillating movement of the planets around the sun. Copernicus's book even features an uncredited copy of a diagram taken from al-Tusi's *Memoir on Astronomy* from 1261.

Copernicus is just one example of a much wider trend. Almost all the famous figures from the history of science in Europe relied on their global connections. When Newton was writing about gravity, he cited experiments conducted in Asia, Africa and the Americas. When Charles Darwin was collecting evidence for evolution, he consulted a 16th-century Chinese encyclopaedia. And when Albert Einstein began developing a new statistical account of quantum mechanics, he teamed up with the Indian physicist Satyendra Nath Bose.

Europe certainly drew on the knowledge of the rest of the world. But there are also plenty of examples of scientists whose breakthroughs have been forgotten, just because they didn't fit into the existing Eurocentric narrative. Take the Japanese physicist Hantaro Nagaoka. In 1903, at a scientific meeting in Tokyo, Nagaoka proposed a new model of the atom. Based on his calculations, Nagaoka established that the atom must consist of a group of negatively charged particles orbiting a large positively charged nucleus. He was right. But today, we tend to remember only Ernest Rutherford, the New Zealand physicist whose article on the structure of the atom was published nearly a decade later.

This is a history that matters in the present. At a time when science continues to have deep inequalities – researchers from minority ethnic backgrounds make up only 12 per cent of the UK science, technology, engineering and mathematics workforce – the need for a new history of science has never been so great.

From Mexican geneticists and Indian chemists to Chinese physicists and Ghanaian biologists, by understanding the true history of modern science and celebrating those whose contributions have been underappreciated, we can help to shape its future in a more inclusive way. ▮

James Poskett is a historian of science and technology at the University of Warwick, UK, and author of *Horizons: A global history of science*

No planet B

The spoils of war

The Russian invasion of Ukraine is first and foremost a humanitarian catastrophe, but the environmental consequences will also be dire, writes **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
Beyond the Hype: The inside story of science's biggest media controversies *by Science Media Centre doyenne Fiona Fox.*

What I'm watching
The Witchfinder *on the BBC. A dark comedic commentary on human irrationality and greed.*

What I'm working on
A surprisingly cheery story about the Black Death.

This column appears monthly. Up next week: Annalee Newitz

A FEW long weeks ago, before Vlad the Invader added the threat of nuclear holocaust back onto the world's roster of apocalyptic horsemen, I received a press release about an idyllic-sounding place called Polesia. It isn't a country, but is big enough to be. This wetland wilderness covers around 180,000 square kilometres, roughly the size of Cambodia, and is of inestimable biodiversity value. Long under pressure from logging, drainage and infrastructure development, it has emerged as a rare conservation success story. On 1 February, the press release was telling of plans to apply for it to become a UNESCO World Heritage Site, Europe's equivalent of the Serengeti.

Today, Polesia is a war zone, pummelled and churned by Russian tanks. Most of the wetland straddles the Ukraine-Belarus border and the assault on Kyiv, launched from Belarus, ploughed straight through its eastern flank. So did the attack on the former Chernobyl nuclear power plant, the environs of which form a key part of the conservation zone on both sides of the border. Russian advances have also begun to edge towards strictly protected areas in central Polesia.

The Russian invasion of Ukraine is, of course, first and foremost a humanitarian disaster. But if and when the dust (hopefully not radioactive) settles, it will also be recognised as an environmental one. Decades of hard-won conservation gains could be wiped out in a matter of weeks. And the environmental threats extend beyond Polesia. Ukraine also includes bits of two other internationally important conservation areas: the Danube delta and the Azov-Black Sea coastline. The former lies partly in Moldova, rumoured to be the next domino Vladimir Putin wants to topple, and the latter is already mired in the conflict zone north of Crimea, which Russia annexed from Ukraine in 2014.

The link between conflict and environmental destruction pulls both ways. Putin's invasion is essentially a throwback to last century's wars of conquest and aggression, but future warfare is likely to be driven, at least in part, by climate change.

This has long been posited as a "threat multiplier", something that tips political instability over the brink into outright conflict. Drought is widely claimed to have been one of the factors that caused Syria to descend into civil war in 2011. For three years prior to the conflict, the once-fertile crescent endured its worst drought on record. Widespread crop failures forced millions off the land and into the cities, doubled grain prices and pushed existing poverty, water shortages and unrest to boil over into violence.

> **"Vladimir Putin cares no more about the destruction of Europe's Serengeti than he does about bombing hospitals"**

This explanation for the Syrian war isn't universally accepted. But it is increasingly clear that climate change really is a threat multiplier. In a recent analysis, Shouraseni Sen Roy at the University of Miami in Florida found that, between 1989 and 2014, warmer years saw significantly more conflict in Asia and Africa, largely driven by the intensification of existing water and food shortages. In Sen Roy's analysis, warmth was driven by the El Niño Southern Oscillation climate phenomenon, but the findings also apply to anthropogenic warming, she says. Other recent work by psychologists at Iowa State University joins the dots between a warmer world and increased violence by showing how heat stress primes people to act more aggressively and to interpret other people's behaviour as aggressive. Heat, in short, makes people hot under the collar.

The UN now recognises the link. In December, its Security Council held a special meeting on climate change, terrorism and conflict. Secretary-general António Guterres reiterated that climate change is an aggravating factor for instability, conflict and terrorism. Russia said it didn't recognise the link.

At the same meeting, the representative of Ukraine explained how Russia's ongoing occupation of parts of its territory was harming ecosystems and making it difficult to remedy the situation. Russia responded by accusing Ukraine of hijacking the meeting to "push forward its warped picture of the world".

The truth is that Putin cares no more about the destruction of Europe's Serengeti than he does about bombing hospitals and killing civilian populations that stand in his way.

A crumb of comfort is that ordering a tank battalion through Polesia arguably qualifies as a war crime. The Rome Statute of the International Criminal Court makes it illegal to knowingly launch an attack that will destroy the natural environment. No person or state has ever been prosecuted under it.

If Putin and his cronies end up where they deserve in the dock in The Hague, I would like to see that added to the charge sheet, if only pour encourager les autres. ▮

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Hospice Ethiopia UK**

Help us bring palliative care where it's most needed

You can support the most desperate people in Ethiopia through Hospice Ethiopia UK (HEUK). The charity dates back to 2011, and was formally registered in 2017. We promote the provision of palliative care – that is, medications and expertise to manage symptoms such as pain and nausea in those who are dying.

Of Ethiopia's approximately 117 million population, few have access to specific cancer treatments such as chemotherapy, and so palliative care is the only realistic option for most. Huge numbers die without even basic medical and nursing care. The current civil war and coronavirus pandemic magnified this problem, leading to a major humanitarian crisis. Inflation is estimated to be 40% at the time of writing.

HEUK supports Ethiopia's first community palliative care programme, called Hospice Ethiopia (HE), in the capital Addis Ababa. HE relies entirely on donations and grants from key partners to fund its work. Along with the home-based care of the terminally ill, HE carries out education projects in Ethiopian hospitals and medical schools. We at HEUK provide approximately half of the annual running costs of the hospice, as well as funding training for their staff. Over the last 10 years HEUK has also funded their home care programme and helped with educational projects.

HE has also been influential in the compilation of palliative care guidelines for use in all government-run hospitals in Ethiopia, thereby increasing access for people to receive holistic care and symptom control as they approach the end of life. Last year HEUK worked with HE and the Federal Ministry of Health to fund the development of a nationally recognised palliative care course with accompanying handbooks for delegates.

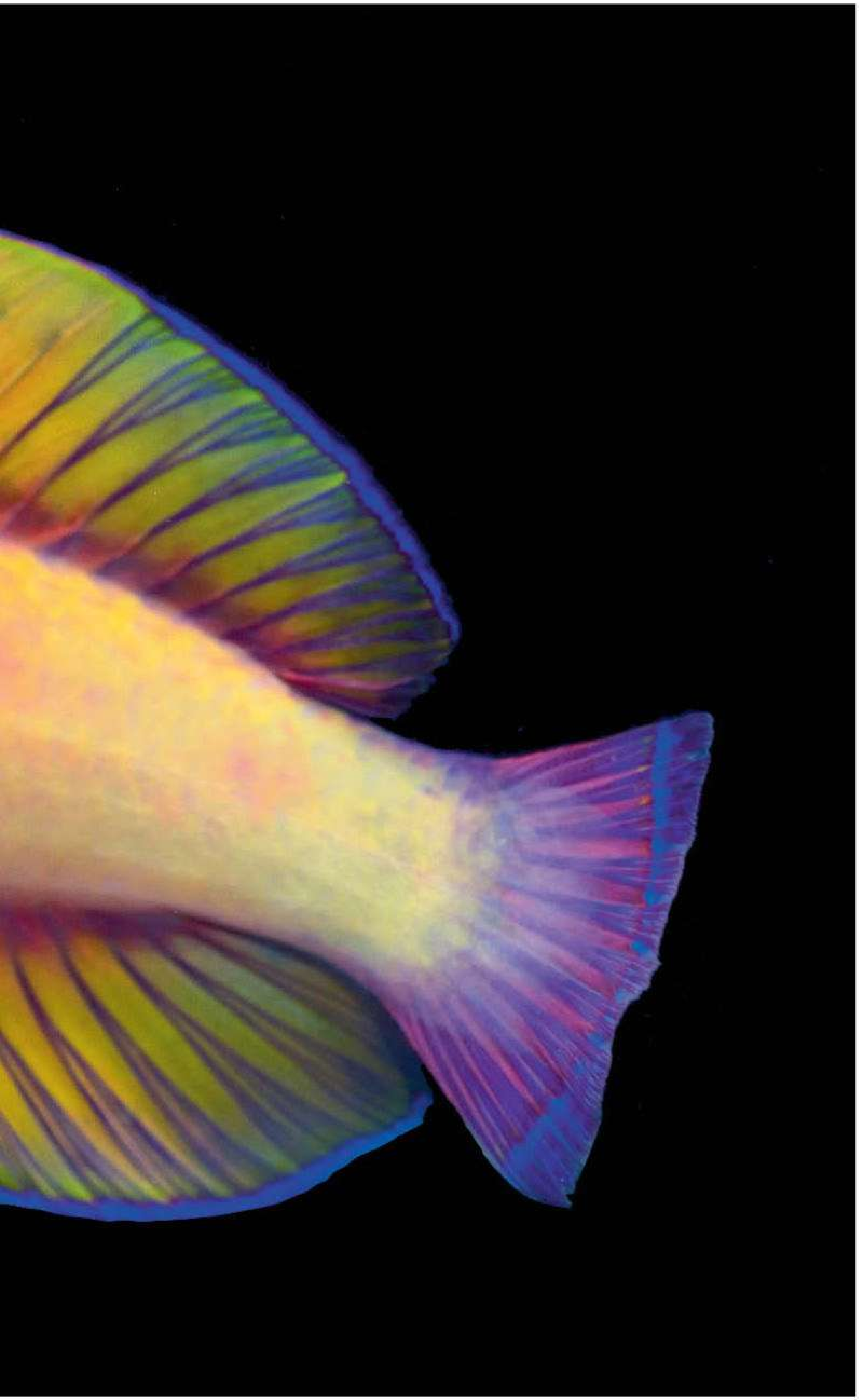
Trustees visit at least annually to understand the challenges facing the team of nurses at HE and to provide direct support. As a small charity we do not employ anyone and trustees fund their own travel, thereby ensuring that every penny donated goes to where it is really needed in Ethiopia.

Our trustees and supporters believe passionately that everyone deserves the right to die with dignity and free from pain; one patient told us. "I thank God for Hospice Ethiopia who have reassured me that they will always care for me. I am prepared for death and am at peace with God."

We need your support

To find out more and donate to our cause, visit the Hospice Ethiopia UK website: www.hospiceethiopia.org.uk

Hospice Ethiopia UK, registered charity number 1171781



Living rainbow

Photographer **Yi-Kai Tea**

THIS vibrant individual is among the greatest living embodiments of a rainbow seen in nature. The rose-veiled fairy wrasse (*Cirrhilabrus finifenmaa*) is a newly described species, having long been mistakenly grouped with one of its relatives, the equally colourful red velvet fairy wrasse (*Cirrhilabrus rubrisquamis*).

An international team of researchers recently found that certain specimens of the red velvet wrasse collected in the Maldives had sufficiently different characteristics, particularly in colouration, to warrant a separate identification. The front third of the male rose-veiled fairy wrasse (pictured), for example, is coloured magenta with a unique dark purple-red central area (*ZooKeys*, doi.org/hk86).

Like most fairy wrasses, the rose-veiled species is mostly found in seas with rubbly seabeds and some coral cover, such as the Indian Ocean, although so far it is only officially known in the tropical waters of the Maldives and Sri Lanka. Its species name is a homage to the national flower of the Maldives, the pink rose, known locally as *fiyatoshi finifenmaa*. ▮

Gege Li

Editor's pick

Bulge science may change, but old difficulties remain

12 March, p 38

From Ursula Arens, London, UK

So, as "Battle of the mid-life bulge" says, slowing metabolism is no longer a valid reason to explain broader girth among 45 to 65-year-olds. Hormones and lifestyles change, and the advice to sleep more and limit stress, where possible, is welcome.

But the what-to-do messages about expanding waistlines – mainly to eat less and also move more – are overfamiliar. The real challenge remains how to translate these much repeated themes into daily choices.

From Jon Arch, Welwyn Garden City, Hertfordshire, UK

A study mentioned in the article found that between the age of 45 and 65, most of us put on 0.5 to 1 kilogram of body weight per year. This rate of gain corresponds to about 0.5 to 1 per cent more energy intake than expenditure.

Whether the overall increase in fat is due to increased energy intake, decreased expenditure or both can't be determined because the imbalance is so small. In any event, this is a secondary consideration. We all know that we should sleep well, restrain our food intake and exercise.

Sea level threat is undoubtedly real

Letters, 12 March

From Nigel Tuersley, Wardour, Wiltshire, UK

Eric Kvaalen argues that scientists have exaggerated the impact of a 5-metre rise in sea levels, and says we can adapt over generations so a "massive refugee crisis" doesn't transpire.

I disagree. There is no exaggeration and the refugee crisis will be real, but it may remain hidden to many as more and more countries build impenetrable barriers to climate migration or adopt blanket exclusion policies.

We may already have a long covid drug test group

26 February, p 38

From Paul Wood, Glaisdale, North Yorkshire, UK

Michael Marshall mentions types of medication that have been identified as possibly protecting against long covid. These include aspirin and atorvastatin. I have been taking these daily for several years since having a heart attack and I believe they are routinely prescribed for this in the UK.

I caught covid-19 in January 2022, confirmed by testing. I don't have long covid. Since there must be many people with heart conditions taking these drugs, I wonder if this could give us the opportunity to correlate the possible effectiveness of such medication against long covid.

Many flying creations don't even need a tail

19 February, p 22

From Guy Inchbald, Upton on Severn, Worcestershire, UK

You report research on the barn owl's tail that could inform aircraft design. But whether efficient aircraft should have tails at all has been long debated. There are many examples of tailless aircraft and drones, plenty successful.

Ultimately, whether a flying machine or creature will benefit from a tail depends on what it will be doing up there. Soaring seagulls tuck their tails away when flying efficiently in still air, while few bats have found the need to evolve tails at all. On the other hand, the crow – and, it seems, the barn owl – can't do without one.

We need to choose carbon capture species carefully

19 February, p 20

From Steve Hackett, Cotgrave, Nottinghamshire, UK

Your article on climate change mentioned some farmers in the UK replacing cereal crops with fast-growing *Paulownia* trees. This is a highly invasive species in the US that is already destroying native ecosystems there.

Although the prospect of a hardwood tree that can grow nearly 5 metres in a season seems tempting, it will be impossible to control. Each tree can produce 20 million seeds, which will be dispersed by the wind and will outcompete native trees. Selling *Paulownia* is already banned in Connecticut and other US states may follow soon.

How to get the circular economy really spinning

12 February, p 38

From Jeff Dickens, Strachan, Aberdeenshire, UK

We can't assume manufacturers will willingly get on board with a circular economy, given the temptation of planned obsolescence.

I had a flat-screen TV fail. The maker quoted £300 for a new circuit board, also suggesting I could replace the TV. On opening it (I have some competence in electronics), I found the cause: four capacitors had "blown". I was able to repair the TV by replacing these at a cost of less than £1.

The capacitors had a rating about half of what it should have been for the circuit. It very much looks like this was deliberately planned and constructed to yield early failure to drive replacement or unnecessarily expensive repair.

A functioning circular economy will need legislation to ensure that all stakeholders play fair.

From Alan Stewart, Crediton, Devon, UK

The elephant in the room as far as waste goes is sewage. We produce huge amounts of it and it creates methane as it decomposes. In large sewage works, the methane is used to power machinery and to mix material by bubbling it up through new sewage.

If surplus methane were sold and injected into the gas supply system, this would achieve circularity. Perhaps we could also decompose grass and other vegetation in anaerobic digesters to create sufficient methane to carry on using our gas boilers – much better than scrapping them and installing costly heat pumps.

From Carl Zetie, Raleigh, North Carolina, US

Recent articles and letters have highlighted the importance of "waste not, want not" to reduce our environmental impact. Even more powerful is an approach we might call "want not, waste not": by reducing our desire for ephemeral or short-lived possessions for which we have no real need, we can have an even greater effect.

Such a philosophy has deep roots in society, including the Quaker adage to "live simply, so that others may simply live", and William Morris's famous aphorism: "Have nothing in your houses that you do not know to be useful or believe to be beautiful."

From Joe Oldaker, Nuneaton, Warwickshire, UK

While agreeing that equipment should be longer-lived and repairable, I suggest that your readers who wanted a new spice and nut grinder (Letters, 26 February) invest in a pestle and mortar for the spices and a strong knife and chopping board for the nuts. Good quality versions will last a lifetime and require no electricity.

Want to get in touch?

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The great bug robbery

The latest true-crime series to hit the small screen takes an intriguing heist just a little bit too seriously, says **Elle Hunt**

TV

Bug Out

Ben Feldman

IMDb TV

ONE morning in August 2018, the chief executive of an insectarium and butterfly house in Pennsylvania arrived at work to find all his live exhibits had disappeared. "Shelves and shelves and shelves that should have been filled with creatures aplenty were empty," says John Cambridge.

As tales of true crime go, the "Philadelphia bug heist" was immediately intriguing, not least because of the obvious question: what could anyone want with thousands of insects?

Now, the hunt for the perpetrators has been given the *Tiger King* treatment in a four-part documentary series for IMDb TV. As with the 2020 sensation featuring Joe Exotic, the most eyebrow-raising moments in *Bug Out* come care of its subjects that walk on two legs.

The Philadelphia Insectarium & Butterfly Pavilion grew out of a 1970s pest-control business called Bug Out that was run by an ex-cop who would display his "catch of the day". Over the years, the displays got more elaborate and eccentric, and insect enthusiasts were drawn to them like moths to a porch light. It grew into the US's first invertebrate zoo and, until the robbery, was a family-friendly attraction that chugged along seemingly without incident.

The series follows a broadly chronological structure, starting with the theft before spiralling out into the strange (and surprisingly endearing) world of hobbyists, collectors and traders of creepy-crawlies. On one level, it is an eye-opening insight into an unfamiliar – and, to many, unappealing – pastime, where people are eager to share their enthusiasm for rare cockroaches ($500 a breeding pair) and African land snails the size of small dogs.

A diversion into the booming illegal international trade in rare bugs and other wildlife shows the darker side of human nature, and our obsession with collecting and commodifying every aspect of the natural world.

But just as you didn't watch *Tiger King* to learn about big cat conservation, *Bug Out*'s real intrigue comes from the people behind the insectarium. In many ways, it is a study of what was a dysfunctional workplace that put human nature, not insects, under the microscope. The most emotionally affecting moments come from employees who fervently wanted to indulge their passion through their work, only to have their dreams crushed by a toxic working environment.

> **"Just as you didn't watch *Tiger King* to learn about big cats, the real intrigue comes from the people"**

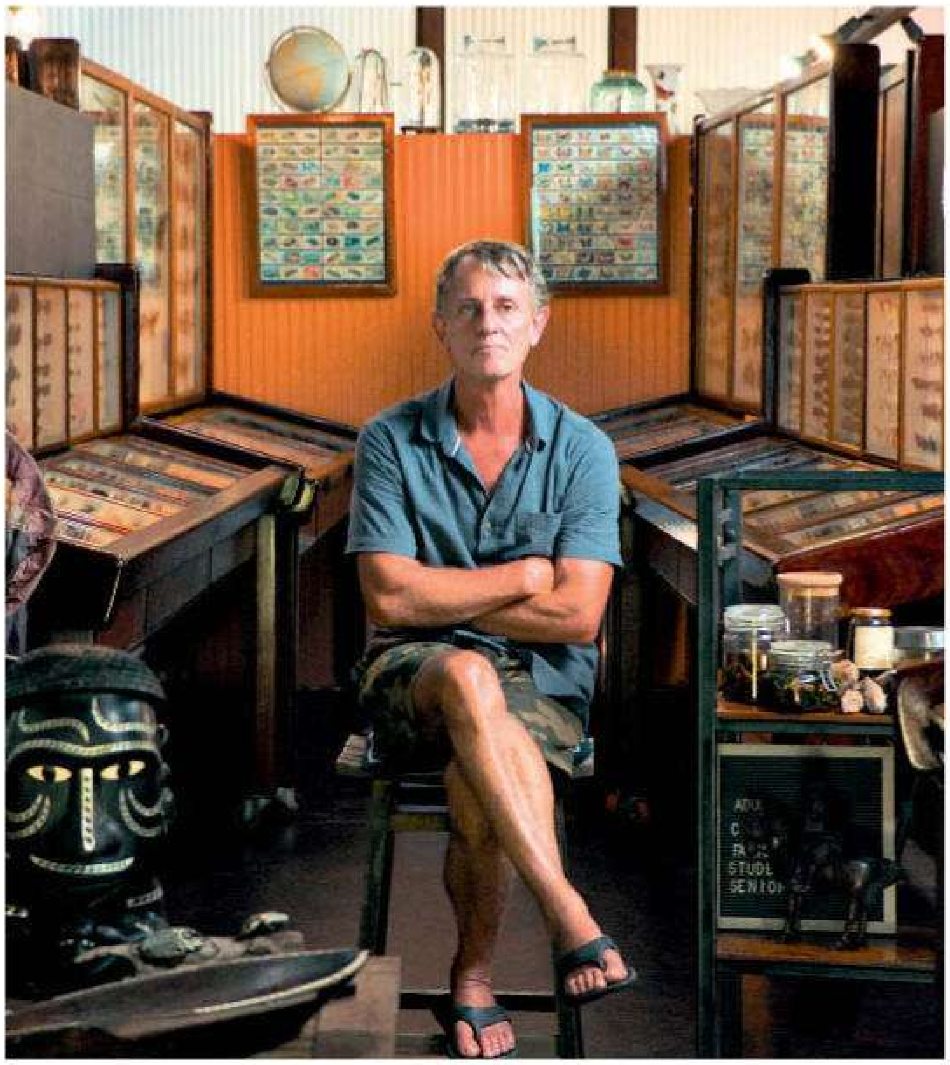
Until the robbery, these dramas played out on a small stage. Then, the heist was picked up by local media and then national media. Before long it was being discussed by late-night chat-show host Jimmy Kimmel. As a result, Cambridge became a mini-celebrity and the police operation hotted up, with an additional FBI investigation that scrutinised some of the then employees' surprisingly shady backgrounds.

The crime was more serious than it might sound: Cambridge put the value of the 7000-odd insects taken at as much as $50,000. But the loss of his exhibits was just the tip of the iceberg, as the seemingly wholesome family attraction was revealed to be beset by power struggles and financial mismanagement.

The documentary-makers' efforts to stoke the drama to true-crime levels are occasionally heavy-handed, suggesting an anxiety about letting the story speak for itself. A dramatically lit corkboard linking suspect mugshots with sticky notes labelled with things like "motive = bugs" is presumably intended to lend drama to the police investigation. The dry humour of the investigating officers, meanwhile, is wasted by the overall po-faced tone of the show.

When the big reveal comes, in the fourth and final episode, it doesn't quite deliver on the whodunnit promised in the first – in fact, it reveals the narrative to have been somewhat contrived. One gets the sense that the film-makers, having set out to tell the true story behind the Philadelphia bug heist, discovered a vastly different tale to the one they had anticipated and were forced to make the best of it.

The result is a highly diverting although somewhat unsatisfying series: a can of worms that, despite *Bug Out*'s best efforts, cannot be tidily contained.



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Bug Out **reveals the world of insect collectors like Steve Lamond**

Elle Hunt is a freelance writer based in Norfolk, UK

Eyes wide shut

A hallucinogenic light and art installation could reveal much about the nature of consciousness, finds **Carissa Wong**

Exhibition

Dreamachine

Jennifer Crook

Unboxed Festival

IN THE late 1950s, when altered states of consciousness were all the rage, the artist Brion Gysin invented a drug-free route to psychedelic euphoria. His Dreamachine – a spinning cylinder that shines flashing lights onto a viewer's closed eyes – was intended as a shortcut to spiritual enlightenment for the masses.

Now, art producer Jennifer Crook has revisited Gysin's invention as a sci-art multimedia experience. The aim is to produce a communal head trip that will not only expand visitors' experience, but also probe the depths of human consciousness.

Crook got the idea for the project after having a transcendent experience while at a gig by electronic music artist Jon Hopkins. She went on to enlist Hopkins to provide the soundtrack to the updated Dreamachine, which will be touring the UK as part of the Unboxed Festival.

At the centre of the installation are vivid hallucinations created by the brain in response to specific sensory inputs. In the 1950s, the pioneering neuroscientist Grey Walter discovered that dreamlike hallucinations could be induced by lights flashing on closed eyelids at 8 to 12 hertz, the same frequency as the oscillations of "alpha" brainwaves when we are relaxed and wakeful with our eyes closed. Normally, when we open our eyes, these alpha waves are disrupted by visual inputs. Flashing lights at alpha wave frequencies on closed eyelids stimulates the optic nerve, but provides little visual information, and the brain responds by generating hallucinations.

DREAMACHINE-BRENNA DUNCAN

Dreamachine's light and sound show can produce intense hallucinations and a sense of calm

Because of this, the Dreamachine can produce kaleidoscopic visions and a sense of calm. These hallucinations may also reveal a lot about the way the brain works. As part of the project, neuroscientists Anil Seth and David Schwartzman at the University of Sussex, UK, are collecting the experiences of visitors, which they hope to use as a window into the workings of the brain. Seth is among the many scientists who believe that hallucinations are part of the way that our brains generate our conscious experience of the world.

One major question concerns perceptual diversity – how varied or similar our internal mental experiences may be. We know that we all see the world in different ways, but science can't yet explain how and why. In an attempt to investigate this, an optional survey will ask participants to log their visual experiences using colour palettes, animations and shape selections.

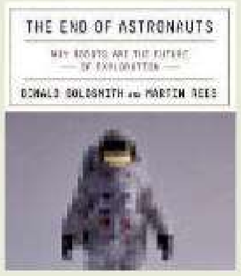
Other questions will address the emotional aspects of the experience, which can be intense. Hopkins's music alone, when played through 360-degree speakers around the audience, can give an eerie feeling of stepping out of time and into a state of being that usually comes with a meditative state.

As well as the physical exhibition, an online census will capture perceptual diversity from millions of people around the world, while a schools programme will be rolled out around the UK. Through activities and resources, children will be encouraged to ask questions about how they perceive the world and to explore how this differs from the experiences of others. The research team's resident philosopher, Fiona Macpherson, says the goal is to show them how, in our differences, we are all connected.

This aim brings Dreamachine back to the ideals of its inventor, who hoped to give people the experience of being catapulted into a higher level of consciousness. Crook's new vision is even more ambitious: to explore the depths of the human brain while realising the variation in our inner worlds and celebrating neurodiversity.

Dreamachine will tour London, Cardiff, Belfast and Edinburgh from May to September. Sign up for free tickets at dreammachine.world.

Don't miss



Read

The End of Astronauts is nigh, say astronomer Martin Rees and science writer Donald Goldsmith. They argue that, given the vast distances and the dangers involved in space travel, it is robots, not humans, that will lead us to the stars.

Play

Death Stranding, from game creator Hideo Kojima, gets a substantial makeover in this director's cut edition, which launches on PCs from 30 March. You play as Sam Bridges, who is on a mission to reunite a shattered world.

Watch

Are Plants Intelligent? asks philosopher Stella Sandford in this online talk from the Linnean Society of London. In light of new evidence, should we rethink our anthropocentric view of intelligence? 30 March, 12.30pm BST.

KOJIMA PRODUCTIONS/IGDB

In the line of fire

An intimate portrait of a couple driven by adventure reveals lives well lived yet tragically cut short, finds **Katie Smith-Wong**

Film

Fire of Love

Sara Dosa

CPH:DOX film festival

ON 3 June 1991, Mount Unzen, an active volcano near Nagasaki in Japan, erupted and sent a deadly pyroclastic surge of hot gas and ash down the mountain. In its path with their cameras rolling were Katia and Maurice Krafft, a married team of French volcanologists and film-makers, renowned for their incredible close-up footage of eruptions. They were killed, along with 41 others.

The Kraffts' careers and relationship, both personal and professional, are the focus of *Fire of Love*, a documentary that premiered at this year's Sundance Film Festival in Utah and will be shown this month at the CPH:DOX festival in Copenhagen, Denmark.

Directed by Sara Dosa and narrated by the actor and director Miranda July, the film explores the parallels between the love the Kraffts had for each other and their joint passion for capturing Earth's fury on film.

Dosa delivers a romanticised vision of the Kraffts' work as they capture stunning images of eruptions and collect data from the edge of volcanoes, while seemingly embracing the dangers of being so close to the action.

For Dosa, their personal relationship is key to making the whole enterprise work. In archive footage, each openly admits that they can't function without the other. Katia meticulously examines rocks and takes samples with a careful eye, while Maurice's bold nature pushes them to seek out bigger and better pictures and to get closer to the action.

The ever-present threat of molten lava seemingly did nothing to dampen their enthusiasm. Throughout the documentary, the footage reveals the pair's charmingly innocent wonder and fascination with their subject. In one scene, we see Katia at the edge of a volcano with no protective gear as lava spurts out. She stands, looking up in awe, seemingly unconcerned by the molten rock raining down around her.

Yet while this sounds like the work of thrill-seeking adrenaline junkies, the film depicts the Kraffts not as reckless or foolhardy, but as a loving couple consumed by a mutual curiosity and passion for adventure.

But the documentary isn't all about romance and excitement. Brief animated segments about the history of volcanoes give *Fire of Love* a more educational tone, in which we learn about volcanoes and the devastating fallout of their eruptions. Two notable examples are the 1980 eruption of Mount St Helens – which killed 57 people, including a close friend of the Kraffts', the volcanologist David Johnston – and the 1985 eruption of Nevado del Ruiz near Armero, Colombia, which killed at least 23,000 people.

Through these examples, we see that the legacy of the Kraffts' work extends beyond exciting images. Their footage has been instrumental in illustrating the dangers that eruptions pose to those living in the shadows of volcanoes and persuading authorities to put evacuation plans into place to protect them. The heartbreaking shots of the destruction around Armero in particular show what can happen when volcanologists' warnings aren't taken seriously and swiftly acted on.

> **"The footage reveals the pair's charmingly innocent wonder and fascination for their subject"**

Above all, though, this is a film that celebrates the love story of a brave couple whose dedication changed our understanding of volcanoes, but ultimately cost them their lives.

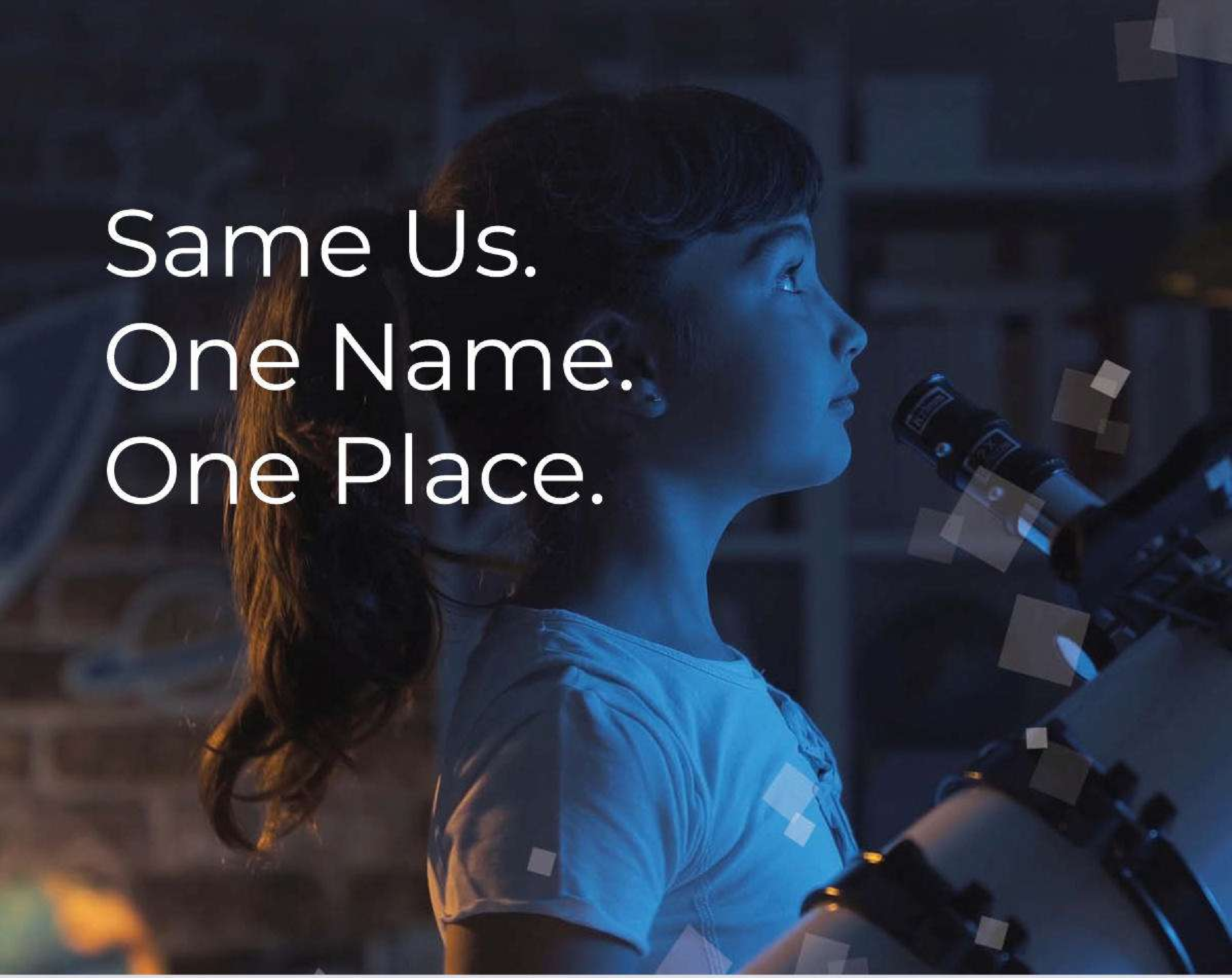
Through stills and video beautifully edited by Erin Casper and Jocelyn Chaput, we get to share the Kraffts' experience of eruptions, seeing Earth's power with an intimacy that is only possible by standing at the edge of volcanic craters.

A nostalgic score brings a whimsical tone to the footage, and presents their lives as a unique moment in time – a captivating and endearing tale of two kindred spirits who wanted to understand the world and to share their passion with others. ▮

Maurice and Katia Krafft (pictured) loved to get close to the action

COURTESY OF SUNDANCE INSTITUTE

Katie Smith-Wong is a journalist based in London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Playing with words

The key to explaining the many mysteries of language is to think of it as a game, say cognitive scientists **Morten H. Christiansen** and **Nick Chater**

IN THE early afternoon of 16 January 1769, HMS Endeavour dropped anchor in the Bay of Good Success on Tierra del Fuego. When Captain James Cook and his crew came ashore, they were met by a group of Indigenous people, probably Haush hunter-gatherers. Two of Cook's party advanced. Soon, two of the Haush also stepped forward, displayed small sticks and threw them aside. Cook's men interpreted this as an indication of peaceful intentions. They were right: the groups were soon exchanging gifts and sharing food. With no common language and inhabiting utterly different worlds, they could nonetheless communicate through a high-stakes game of cross-cultural charades.

Most of us have faced our own communication challenges, perhaps resorting to pointing and gesturing when abroad. And yet in daily life, we rarely give language a second thought – never mind its many perplexing mysteries. How can noises convey meaning? Where do the complex layers of linguistic patterns come from? How come children learn language so easily, whereas chimpanzees can scarcely learn it at all?

We believe these questions have remained unanswered because scientists have been looking at language all wrong. A growing body of research undermines prevailing ideas that humans possess an innate language ability somehow wired into our brains, encoding grammatical rules. In our new book, *The Language Game*, we argue that language isn't about rules at all. As Cook's encounter illustrates, it is about improvisation, freedom and the desire to be understood, constrained only by our imaginations. This radical idea helps to explain those long-standing mysteries about language – as well as how language evolved and why it makes humans special.

For generations, scientists have sought to understand how the rules of language derive from biology. The founding figure in modern linguistics, Noam Chomsky, has long argued that language is governed by a "universal grammar" somehow built into our genes and brains, with specific grammars of individual languages as variations on this universal blueprint. More recently, psychologist Steven Pinker at Harvard University proposed that humans have an evolved language instinct, created by natural selection.

Origin myths

Even as young researchers, we saw several reasons to doubt the belief that language has its primary origin in biology. For a start, languages change much faster than our brains can evolve. It took less than 8000 years for languages as diverse as Danish, Hindi, Polish, and Waziri to evolve from a common proto-Indo-European origin, for example, whereas human evolution is on the timescale of hundreds of thousands of years. Besides, evolution has no foresight, so couldn't have adapted our early ancestors in Africa to deal with the subsequent spectacular diversity of the world's languages. Rather, biological evolution adapts organisms to their local environment, as illustrated by Charles Darwin's studies of Galapagos finches, which revealed that the birds had evolved into different species with beak variations each exquisitely adapted to crack nuts, eat cactus fruits or catch insects. If language evolved through biological adaptation, we would expect distinct adaptations of innate grammars to the different local linguistic environments. But this isn't the case: distantly related populations show no signs of having brains adapted to their particular language. After all, across the world, immigrant children easily learn the language of their new home.

If language doesn't come from biology, then, where does it come from? We believe the answer is culture: language evolution is cultural evolution. And that, we argue, requires a rethink of how language works, too. It isn't a game of tennis in which messages are lobbed back and forth between minds, which systematically extract the information. As Cook's meeting with the Haush reveals, people collaborate to build a shared understanding incrementally, improvisation by improvisation, just as in a game of charades. If we are correct, the world's 7000 or so different languages are the result of countless

HARRIET NOBLE

repetitions of such charade-like games.

Of course, biology still plays a role. There is no doubt, for example, that particular regions of the human brain are especially involved in language, and that the nature of our vocal tract is crucial for allowing us to articulate words. But our species didn't evolve a specific instinct just for language. Instead, our ability to play linguistic charades piggybacks on various skills that predate the emergence of language. In this respect, language resembles reading. Until about a century ago, few people could read and write, so literacy can't be a biological adaptation. Instead, it is a product of cultural evolution, argues Stanislas Dehaene at the Collège de France in Paris. And writing is shaped by pre-existing cognitive abilities, including an ancient primate visual system, which helps to explain the puzzling discovery that ›

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baboons can distinguish English words from nonsense sequences of letters. Likewise, the human brain has shaped language. Indeed, we find it useful to think of language as a self-organising evolutionary system – an organism adapted to a specific niche: the human brain.

But how could repeated improvised games of linguistic charades generate the grammatical complexity of language? Linguists looking at how languages change over time have uncovered a compelling alternative to Chomsky's universal grammar that provides the answer. Today's grammatical patterns arose through a gradual process known as grammaticalisation, in which words become bleached of meaning and take on purely grammatical roles, while their sounds are often eroded to be easier to say. Consider negation in French. First, the Latin *non dico* (I do not say) becomes *je ne dis* – with *non* eroded to *ne*. Then words such as *pas* (step) are added, as in *je ne marche pas* (I won't walk a step). Over time, *ne… pas* becomes bleached of any meaning about steps, so that a noun for a concrete observable action now has an abstract grammatical role. With grammaticalisation, the patterns of grammar needn't be built into our genes. Instead, they emerge spontaneously over centuries and millennia.

> **"If language doesn't come from biology, where does it come from?"**

MIODRAG IGNJATOVIC/GETTY IMAGES

Child's play: Infants learn to talk with apparently no effort

Then there is the question of how you understand a continuous flow of speech sounds – an astonishing mental feat, as becomes obvious when you hear the machine-gun exchanges of people chatting in a language you don't know. Classic hypotheses generally propose that the brain takes a steady, sequential approach: first assessing what speech sounds we are hearing, then syllables, then words, then gradually building up the grammar and meaning and, finally, figuring out what the speaker is really getting at. But that would be far too slow. Speech sounds disappear in less than a tenth of a second and the human short-term memory for spoken words is limited to just three to five elements. Yet a typical English speaker will produce between around 10 to 15 speech sounds per second and about 150 words per minute.

The brain faces what we have dubbed the now-or-never bottleneck: as the flow of language hits you, you must make sense of it right away. Instead of systematically analysing it, we argue, the brain uses chunking – working in parallel to group sounds into syllables and words, words into phrases, and phrases into sentences before it is obliterated from memory by the onrushing torrent of new speech. Even then, you cannot hope to get much out of this onslaught of language if you rely on the linguistic input alone. Words, phrases and sentences don't carry neatly defined packets of meaning that can be snapped together like Lego bricks. For example, a "door" you walk through isn't interpreted in the same way as a "door" you open. And the meaning ascribed to "light" depends on whether it is being used to describe tanks, wine, colours, infantry or

How to be a better communicator

If language is like a game of charades (see main story), then that has real-life implications. Words, phrases and sentences are only the tip of the communication iceberg. They give clues to meaning, but below the surface lies a whole range of other things that are necessary for us to interpret what is said. These include factual knowledge, cultural and social information – such as customs, norms, conventions, values and unspoken rules – and interpersonal skills.

We can become better communicators by focusing on these submerged attributes. That entails paying close attention to what we have in common with conversational partners and where we might differ, which requires empathy and collaboration. Fortunately, this is something we can learn to do better. In New York, at Stony Brook University's Alan Alda Center for Communicating Science, they use improvisation exercises – such as mirroring the body movements of a partner – designed to get actors to tune into each other's perspective, to help people improve their science communication. The method has been very successful and widely adopted.

What works for scientists also works for everyone else. Whether you are outlining a business plan, telling a story or just giving directions, think carefully about where your audience is coming from and what they might need from you – not just what you want to say.

The kind of improvisations you do in charades could be the key to language evolution

ANDREW LIPOVSKY/NBCU PHOTO BANK/NBCUNIVERSAL VIA GETTY IMAGES

music, say. As in charades, words provide clues that require interpretation. And, as psycholinguist Herbert Clark at Stanford University in California has argued, language is fundamentally a collaboration. It isn't enough merely to analyse speech sounds. Crucially, humans must also interpret them in real time using creativity and whatever shared intuitions, knowledge and memories of past exchanges we can collaboratively muster.

If languages are honed by cultural evolution, through generations of improvised charade playing, that also explains why children can acquire their native tongue with such apparent ease. Language is a communicative tool shaped by the limitations and capabilities of the human brain. Just as physical tools, like scissors, have been shaped by cultural evolution to be easy to use, so too has language. The challenge for each child isn't to master a complex grammatical system, but to use whatever clues they can gather from the immediate situation and past experiences to make themselves understood and understand others in the here and now. And the key to their success is simple: every speaker was once a child too. So the patterns of linguistic charades that children must learn were created by previous generations of language users with similar brains and bodies. This is what makes language easy to learn and use.

To see why, consider this. A scientist collects a sequence of data points – 1, 2, 4, 8 – and wonders what will come next. In the natural world, there are many possibilities: the sequence might repeat, start descending, get "stuck" at 8 or take any number of directions. Alternatively, two people see the same sequence of numbers and must guess what the other will choose as the continuation. In this case, both are most likely to say 16, 32, 64, not because this is the only possible answer, but because it is the mutually obvious one. Similarly, because language is culturally evolved from the interactions of generations of people, the most obvious answer is typically the right one. As a result, children merely need to follow in the footsteps of others who were very much like them. Of course, as with charades, each separate linguistic community will create its own distinctive paths. That would explain the remarkable diversity of the world's languages.

It may seem that our linguistic charades perspective implies language originated in manual gestures. No doubt, gestures can easily mimic different aspects of the world. But sounds have remarkable capacities for mimicry too. Recent research by Marcus Perlman at the University of Birmingham, UK, and his colleagues shows that people can easily come up with non-speech sounds that can mimic all sorts of different concepts – a swoosh sound to denote a knife and quick, repeated swooshes to indicate cutting, for example – and that these novel vocalisations are understood across cultures.

A virtuous cycle

The debate continues over whether language originated in gestures or sounds. Our take is that its beginnings were probably multimodal, because early communicators would have wanted to incorporate as many ways as possible to provide clues for linguistic charades. A virtuous cycle may then have followed: the ability to use an ever-growing set of clues would have increased social complexity, favouring people with bigger brains, which in turn would enable even more advanced charades playing, selecting for the evolution of still bigger brains, and so on. How humans got into this cycle isn't known. It is even possible that language was a side effect of having evolved bigger brains for another reason. What seems clear, however, is that our nearest primate cousins, the great apes, didn't join us. They aren't able to play charades because they lack many of the underlying skills on which it piggybacks. This helps explain why language is unique to humans.

The emergence of language has been described as one of seven major transitions in evolution. It changes everything. It allows humans to pass on knowledge and skills to future generations, rather than being condemned to relearn them afresh in each generation. It allows us to create the complex webs of agreements that underpin our social interactions and groups, as well as creating moral and religious norms to help us coordinate our actions with others. Without language, there could be no legal system, no organised trade or finance, no politics and no cumulative science or technology.

Language is our greatest invention. Without it, our other spectacular achievements would be inconceivable. Yet, if we are correct, all people ever do is play linguistic charades to get their messages across. Each charade can shape the next in remarkable and unexpected ways, but there has never been any plan to create a system for communication to revolutionise human life. Language is the cumulative, but accidental, result of the communicative efforts of countless past generations. The story of language is therefore the story of humanity. ∎

Morten H. Christiansen is at Cornell University, New York, and Nick Chater is at Warwick Business School, UK. *The Language Game* is out now

I AM playing a video game on my phone, making a bird climb and dive to avoid hazards and collect points. It is pretty simple and unremarkable except for one thing: I am using my vagina as a game controller.

The device I am using, which looks like a sex toy and wirelessly talks to my phone via Bluetooth, is designed to encourage users to exercise something that is usually ignored: the pelvic floor. Hidden away at the base of our abdomen, this hammock of muscles, nerves and tissues supports internal organs including the bladder and bowel. It is a critical part of our anatomy, yet most people only start paying attention to it when it becomes too weak – and they experience incontinence – or too tight. Such problems are often thought of as a "female thing", but everyone has a pelvic floor, with weakness also linked to erectile dysfunction.

Recently, there has been a renaissance in our understanding of what the pelvic floor is made of and how it can go wrong. Exercise programmes promise healing, and an ever-increasing array of digital devices, like the one connected to my phone, advertise strength training for these elusive muscles.

But many people aren't getting their diagnoses or treatments right. The best known way to improve control of the pelvic floor muscles is squeezing exercises known as Kegels, but these aren't suitable for everyone and won't fix everything. Some people who would benefit from Kegels are activating the wrong muscles or not working the right ones hard enough. It's time to get to know your pelvic floor better.

The pelvic floor is made up of layers of muscle fibres, which together are roughly the size and shape of two cupped hands, surrounding the urethral openings. This bowl-like structure, which is typically about 10 centimetres wide and 1 centimetre thick, must be strong enough to support the organs above but flexible enough to allow sexual function and the opening of the bowel and urethra, plus childbirth (see "Childbirth conundrum", p 44).

The strength and thickness of the muscles of the pelvic floor vary from person to person, and over time, they are affected by repeated stress and strain from activities such as jumping or trauma due to childbirth. This means they can weaken, over-stretch or tear. "The damage is cumulative," says John DeLancey, a pioneer of pelvic floor research at the University of Michigan in Ann Arbor. All this can contribute to incontinence or, in severe cases, organ prolapse where the rectum, uterus or bladder start to fall out of the body.

Almost a quarter of women are affected by pelvic floor dysfunction, rising to nearly half of women over the age of 80, according to a US National Institutes of Health study. About 1 in 10 women in the US will have surgery for these issues, says DeLancey.

These problems disproportionally affect those who have given birth, who might urinate

Inner strength

The pelvic floor is a vital part of the body that often gets ignored. Is it time for everyone to give theirs a workout, asks **Nicola Jones**

WILLIAM SHERMAN/GETTY IMAGES

a little when they laugh or cough – a condition called stress urinary incontinence (SUI). But younger people can have issues too. A study of female trampolinists in Sweden, for example, found that all of the participants aged between 16 and 22 experienced urinary leakage due to copious jumping.

Male sportspeople can have similar issues. A study of elite athletes in Spain found that 15 per cent of the male participants experienced SUI during their training, especially running and lifting weights. But more generally, problems are most commonly experienced after surgery for prostate cancer, which will almost always bring some degree of urinary incontinence.

The muscles in this area were well documented by 19th-century anatomists, but since then things have got more muddled, with a variety of names given to the same structures, especially for the web of connective tissues surrounding the muscle. This "fascia" remains mysterious, says Mélanie Morin at the University of Sherbrooke, Canada, who last year co-authored a review highlighting all this confusion. The fascia is riddled with nerves and probably plays an important, misunderstood role in pain, she says.

DeLancey became fascinated with the structure of the pelvic floor and how it worked in his early years as a doctor. His investigations threw up some surprises. Back in the 1990s, he says, everyone thought that an unsupportive hammock of muscles was the primary cause ›

> "Almost a quarter of women are affected by pelvic floor dysfunction"

of urinary incontinence. His studies using ultrasound and MRI scans showed instead that it often has more to do with the ring-like muscle that tightens around the urethra.

In the past, if someone's pelvic floor failed, physicians simply shrugged about the details, says DeLancey. Imagine if engineers had the same lack of knowledge about the structural failure of a building or bridge, he says. "Until recently, people just said: 'The bridge failed.' Now we can identify which part failed." His work also showed that childbirth can tear a specific muscle in the pelvic floor region, leaving it dangling from the usual point of attachment.

This is an injury that doesn't heal with exercise, time or even surgery, says DeLancey, although other muscles can often step in to compensate. That has been a double-edged discovery – while it is good to better understand the trauma, it has left many women feeling like they are broken and can't be fixed, he says.

> "Pelvic floor weakness has been linked to erectile dysfunction"

The good news is that physiotherapy can help many other issues, from weak muscles to over-tense ones. But it can be hard for people to know what to do with their pelvic floor. Kegel squeezes – named after the US gynaecologist Arnold Kegel who promoted them in the 1940s – can be frustratingly difficult, like trying to isolate the right muscles to wiggle one eyebrow.

The usual advice is to imagine trying to stop the flow of urine or the passing of gas, without tightening your buttocks, legs or tummy. "Some people clench their fists or teeth, hold their breath, or make a face. This does not help," states the Urology Care Foundation on its website. Those struggling with Kegels can either insert a finger into their vagina to see if they can feel a tightening or lifting, or stand in front of a mirror and try to move their penis up and down without moving any other part of their body. For those who have the benefit of medical supervision, an ultrasound or physical exam can reveal if the right muscles are activating.

Biofeedback can also be helpful. Typically, internal pressure sensors are used to measure the location and strength of contractions. According to physical therapist Kari Bø at the Norwegian School of Sport Sciences in Oslo, co-author of *Evidence-Based Physical Therapy for the Pelvic Floor*, the problem is that many of these devices can't tell if the right muscles are being activated; contracting buttock muscles might produce the same outcome on the screen. The device I am using has two different sensors and tutorials to help prevent this, but it is still possible to cheat by clenching something other than the pelvic floor. When done right, though, such tools can help measure the strength of contractions and evaluate if they are increasing over time.

There is strong evidence that, performed correctly, these exercises can help. "We now have so many randomised controlled trials, and systematic reviews. They all conclude that pelvic floor muscle training is effective," says Bø, and should always be the first line of action before surgery is considered.

Studies show that doing three sets of between eight and 12 contractions, three times a week, is a reasonable target for an exercise programme, says Bø. Do that for six months, she says, and this should tighten and lift the muscles, along with about a 15 per cent thickening of the pelvic floor. A 2018 review of 31 trials showed that women with stress urinary incontinence were eight times more likely to have the problem remedied if they engaged in this kind of training.

Study results are more mixed for men. "There are about 20 good trials, but the results differ more than they do in women," says Bø. "Some studies find no effect; some find excellent effect." The difference, she suspects, may be due to the fact that most men with pelvic floor muscle issues experience these problems as a result of prostate cancer surgery, which causes a different sort of damage. One notable study, however, found that a three-month programme of dozens of

Childbirth conundrum

It has long been a puzzle why the birth canal of modern humans is so narrow for pushing out our big-headed babies, with a relatively high risk of them getting stuck. Other species, including other apes, don't have this problem. This "obstetric dilemma" is often explained by the fact that a narrower pelvis helps us walk upright. Research last year revealed how the mechanical constraints of the pelvic floor muscles might also play a role.

According to the pelvic floor hypothesis, the size of this structure is the result of a trade-off between the muscle stiffness needed to support the inner organs and foetus versus the flexibility needed to push a baby out. To test this, Ekaterina Stansfield at the University of Vienna in Austria and her colleagues developed a 3D model of the pelvic floor and how it changes as the birth canal widens or narrows. They found that a large opening gives the pelvic floor muscles more room to stretch, just as a larger trampoline will have a deeper bounce.

The effect was dramatic: an increase from an 11-centimetre-wide pelvic floor to a 13-centimetre-wide one, for example, resulted in a 50 per cent greater bend in response to pressure. "Size matters," says Stansfield. The bigger the stretch, the greater the risk of dysfunction like incontinence or organ prolapse.

Evolution could theoretically compensate for this extra stretchiness by developing thicker muscles. But Stansfield's team found that the pelvic floor would need to be at least twice as thick to support a 13-centimetre opening versus an 11-centimetre one– and that comes with negative effects on childbirth. Previous work has shown that athletes with thicker pelvic floor muscles need to push 45 per cent harder to get a baby out. At some point, says Stansfield, you hit the limits of what a woman can do.

THOMAS M. BARWICK INC/GETTY IMAGES

The pelvic floor has to withstand the pressures of strenuous exercise

daily contractions helped to restore erectile function in a group of men. Only 25 per cent of the participants didn't improve.

Regular training

Although most studies are carried out on people experiencing issues with their pelvic floor, there is some evidence that doing exercises before problems arise can have a preventative effect: those who practice Kegels before giving birth or having prostate surgery, for example, tend to have better control over urine flow afterwards, at least in the short term. Similarly, pelvic floor function was improved for transgender women who underwent gender-affirming vaginoplasty surgery to create a vagina if they attended physical therapy training beforehand.

For these preventative reasons, the authors of the study of Spanish athletes recommended that pelvic floor exercises should be part of athletic training programmes. Pelvic floor health is also part of the national healthcare plans in certain counties. In France, for example, postnatal "perineal re-education" physical therapy classes are sometimes prescribed, and are much touted in the media with headlines such as "Why French women don't pee their pants when they laugh". Surprisingly, though, there is little if any evidence that this has a significant effect on levels of pelvic floor dysfunction or surgeries for French women, says Bø.

Like with any muscle-building activity, you have to work hard to get results. "It is a problem that many women aren't contracting strongly enough. It's like doing this," says Bø, flapping her arms, "and expecting to build up your biceps." When I ask Bø why my own Kegel attempts feel so frustratingly inconsequential, without the typical muscular burn I experience from other exercises, she implies that I am simply not doing it right. "I have had women who say they can feel it the day after," she assures me.

This is one area where biofeedback might help, because having the exercises be part of playing a game makes it easier for some people to get motivated and work hard. However, many studies indicate that women don't need such devices to benefit from Kegels. And the advertising for some of these devices might give women the incorrect impression that Kegels will fix absolutely everything "down there", says DeLancey. "There's a lot of voodoo in this area," he says. "We shouldn't be asking millions of women to do something that isn't necessarily going to work for them." Some women have muscles that are so weak they simply won't be able to do Kegels even if they try their hardest, says Morin. She suggests that electrostimulation of the muscles might help them to build these up to a level where Kegels are a possibility – yet another reason why it is so important to get advice from a pelvic floor specialist before starting an exercise regime.

DeLancey also often directs people to myconfidentbladder.org, which provides exercises and simple coping tricks for dealing with a weak pelvic floor, such as waiting to have that third cup of coffee until after your commute, or setting an alarm to empty the bladder at 4am. Another common trick, often called "the knack", is to activate pelvic floor muscles just when you feel a cough or other problematic moment coming on, which can dramatically reduce urine leakage.

Recommendations are different for those who instead experience a painful, over-tight pelvic floor (sometimes diagnosed as vulvodynia). This may be due to physical pain from another cause, such as endometriosis, which puts the whole area on "high alert", and can lead to complications after vaginoplasty surgery. It may also be influenced by psychology, says Morin – if someone is afraid of sex or unable to relax with their partner, for example, this can make the pelvic floor tighten in the same way as people who sometimes suffer from tight muscles in the shoulders or jaw. This area has been radically understudied, says Morin. Internal massage and physiotherapy can help, she says. While the goal of strengthening muscles by tightening pelvic floor muscles may not be relevant, the idea of gaining enough control over them to consciously relax (the other half of a Kegel) is helpful, she says.

That kind of control is what my app is now training me to gain, as I learn to tighten and relax a part of my body that I never thought about before giving birth. For me, Kegels have become yet one more exercise to add to my weekly regimen of cardio and weights, in hopes of staving off all kinds of physical issues as I age. I take a deep breath, and get the bird to move around the screen – aiming for a new high score. ■

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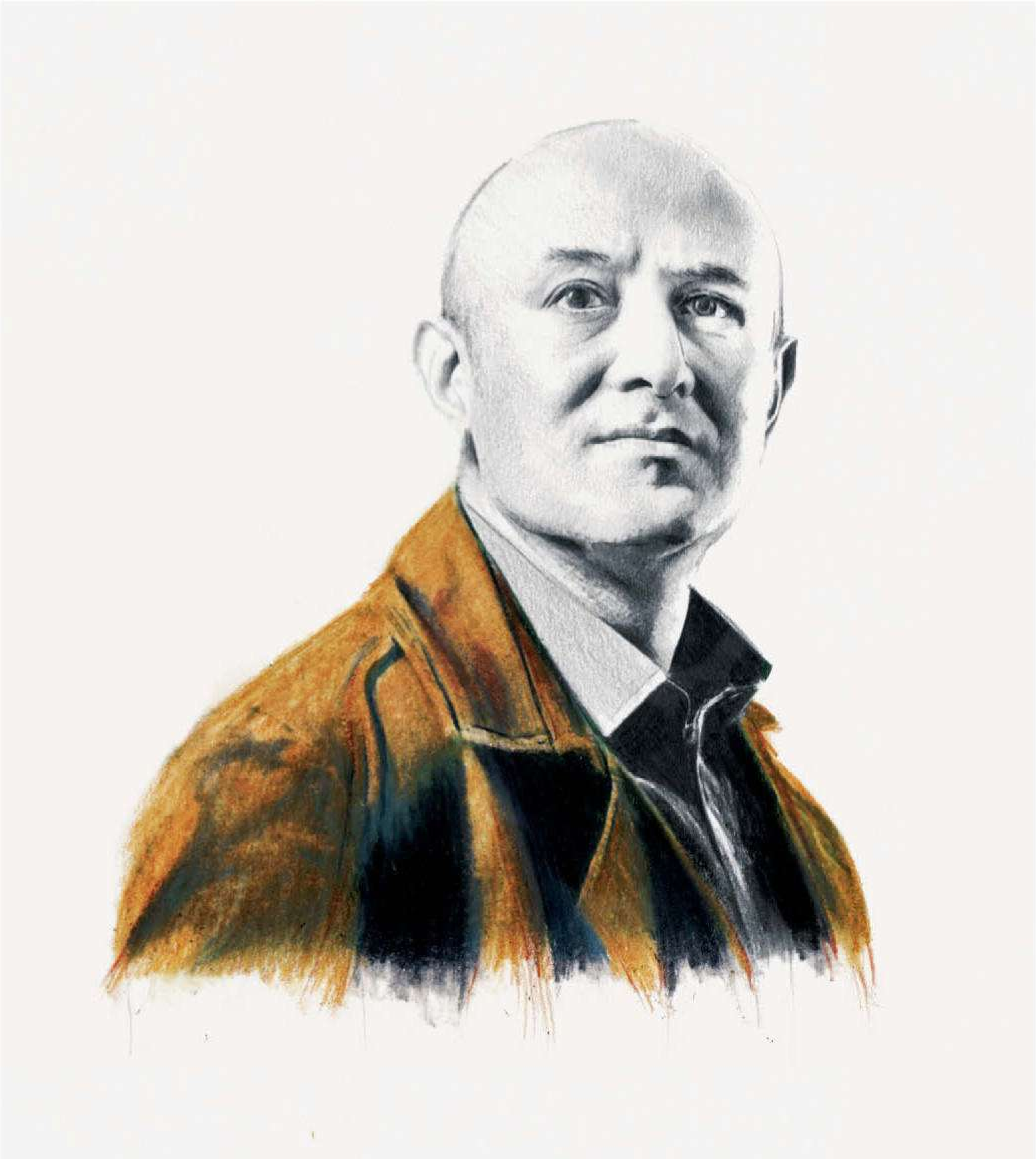

NABIL NEZZAR

"Everyone should be able to see why science is so joyful"

In a world that tries to rob adults of their childlike wonder and curiosity, physicist and broadcaster Jim Al-Khalili has kept a firm hold of his throughout a 30-year career. He shares his secrets with **Richard Webb**

IT SEEMS nobody spends quite as much time discussing the joys of science as Jim Al-Khalili. Whether with guests on his BBC radio programme, *The Life Scientific*, in the documentaries he presents or with the students he teaches and mentors at the University of Surrey, UK, he is on an insatiable quest to find out "why". He told us where this all started, why scientists need to question their own biases and about the importance of never growing up.

Richard Webb: To turn the tables a bit, what made you take up a life scientific?

Jim Al-Khalili: I guess my passion for science, well, physics, began in my early teens, when I was obsessed with football and discovering girls and thinking I'd one day play for my beloved Leeds United, who were a good team back then in the mid-1970s. But I suddenly fell in love with physics. It was like puzzle solving; it was common sense. With chemistry and biology, I had to remember stuff, and I'm terrible at remembering stuff. Physics also dealt with the big questions. Where does the universe come from? What does an atom look like? What's inside a star? So from about the age of 13 or 14, I wanted to do physics. If I got to play for Leeds United, that would be nice, but I was going to be a physicist.

Your latest book is called *The Joy of Science*. Is that something you feel on a day-to-day basis?

It is, actually. Part of why I enjoy science communication is that I like doing the science. I like finding out stuff for myself, and I can't imagine not sharing it with as many people as possible. If you discover something new about the world, why would you not want to shout it from the rooftops? Everyone should be able to see why science is so joyful, why understanding how the world works, is something to celebrate.

You are a theoretical physicist, and that feels very different from what, say, a climate scientist or someone discovering new vaccines might do. So what actually is science?

What I try and get across in my book is that science isn't about facts about the world. That's called knowledge. Science is a process, a way of getting to that knowledge. And that could be sitting observing birds nesting on a cliff's edge, it could be digging into the ground to understand geology, it could be solving algebraic equations, it could be writing mathematical computer programs to model the climate or it could be working in the lab with lasers or test tubes or whatever.

So science is about getting closer to the truth?

Absolutely. And I think, these days, there is this perception that truth is what you make of it. It is relative. But in science, particularly in the natural sciences, there is an absolute truth. Wherever we come from, whatever culture, whatever time period, whatever language we speak, we should be able to reach that truth about the world.

With all the misinformation and conspiracy theories flying around, are we turning away from a scientific way of thinking?

The pandemic has taught us we can't face up to the challenges of the 21st century without science to develop the vaccines, to understand the nature of pandemic spread and so on. And we're learning more as a society about how scientists work, how they think and what the scientific method is. But there does seem to be a rise in misinformation and irrational thinking as well. That's very difficult to combat, because the people who buy into irrational ideologies think they're behaving ›

New Scientist Video
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scientifically, that they have an inquiring mind, that they are doing all the things that the scientific method tells us to do. But they're arriving at something that is not the truth.

How do we convince them of the truth?
If there's someone who is adamant Earth is flat, or that we didn't go to the moon, or that alien abductions are real, in a sense it doesn't matter. The world would be a boring place if we all believed the same thing. But when you come to people spreading lies about vaccines, for example, we do have to do something. You can't shout your way into getting someone to agree with you; you can't say they're being stupid. I think the way to tackle conspiracy theorists is to accept that they truly believe what they do believe, but also get them to understand there's such a thing as cognitive dissonance – that they will be uncomfortable in hearing something that goes against their existing beliefs. We all need to examine those biases and beliefs we have and examine where we got our evidence from.

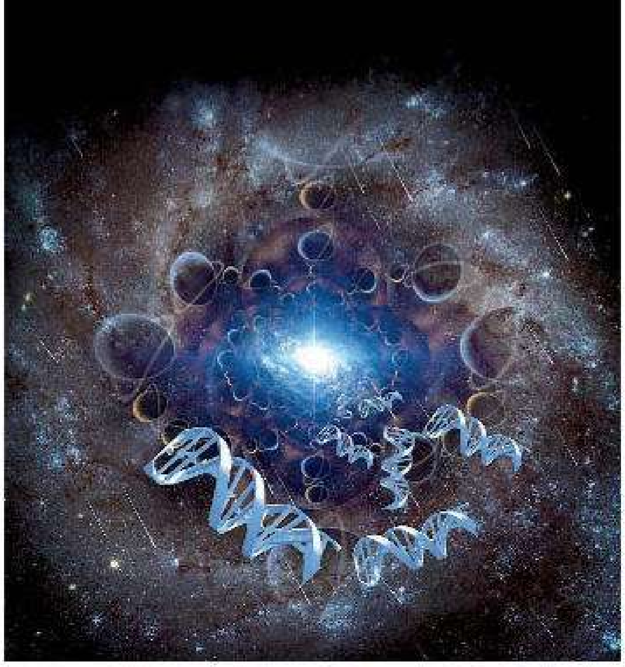
Science prides itself on being objective, but doesn't it have its own problems with biases?
Scientists are people, too, so they will have their own ideological views and motivations, whether it's to get funding or to push a particular hypothesis they've invested a lot of years into. The difference is that we have the scientific method, as we've developed it over the centuries, which has been designed to correct for our biases. Things like reproducibility: you can't just say "I've discovered this", other people have to repeat that experiment or that observation and see if they get the same results.

Bad ideas don't survive in science. There are certain dogmas that last because people fall into a way of thinking, and then you get the lone Einstein who comes along who says: "Actually, you were all wrong." The problem is, everyone thinks that they're the new Einstein if they don't agree with the consensus. But the scientific method corrects for this in general. It's one step backwards, two steps forwards, but ultimately, we tend to overcome those biases.

Does it help overall trust in science when in climate science, for example, scientists are increasingly also activists?
I can see why people would regard that as science becoming ideologically driven, rather than rationally driven. But I think the activism connected with climate change is really to try and get the point across that while we're never sure in science – you can never be certain – with overwhelming probability things are going badly. I think sometimes you do have to shout about it when people aren't listening. I see the activism not as political ideology, but as a necessary thing we have to do to persuade people to change their ways.

As well as a champion of science, you are a prominent humanist. Do you think religious belief and scientific thinking are incompatible?
By and large, if you are a laser physicist or an engineer or an organic chemist, if you have a religious faith, that's not going to affect your ability as a scientist. But ultimately, a scientific view of the world does not call upon any supernatural explanations. There are very clever and very rational scientists, many of whom are good friends of mine, for whom their religious faith is very important, and I wouldn't presume to argue with them or belittle their reasons for believing in what they believe in. But ultimately, as a scientist, I want to find a non-supernatural explanation that obeys the laws of physics. My personal view is that it's intellectual laziness to reach a point and say: "Well, I can't understand things further, it's down to a divine creator."

"Science is constantly taking us beyond what we thought we could understand"


BRUCE ROLFF/ALAMY

But in your area, fundamental physics, don't we eventually reach the point where we can't understand things further?
Certainly. One example is in cosmology. How did the universe start? In the big bang, when space and time started. Well, what caused the big bang? If you go purely by Einstein's theory of relativity, there is no earlier time than the big bang, because that's when time was created. You get that far with "how did the universe begin" and you say "it just did". Yet, nowadays, cosmology suggests that maybe there was a before, that maybe our universe was born in a big bang that wasn't unique, that there are other big bangs, other universes popping into existence. What we once thought was the limit of where we could possibly get to in understanding, we later realise we can push back. Science is constantly taking us beyond what we thought we could understand.

But when cosmology starts saying there are other universes out there that we can know nothing about, isn't it straying into that "just take it on belief" territory?
In a sense, yes. The same applies with various highly mathematical theories like superstring theory. There are many scientists who say if you can't design an experiment to test your theory, you're failing one of the conditions of what you define as science, testing hypotheses. But there are reasons mathematically why these ideas make sense, and how rationally or logically they answer questions. I put them above just religious beliefs, because we hope one day to be able to test them. Just because we don't have a way of testing some of these ideas now, doesn't mean they're not part of science.

To move on to a very rigorously tested theory, quantum theory – will we ever understand it?
It depends what you mean by understanding. A lot of physicists get very hot under the collar about this, because quantum mechanics as a mathematical framework, describing the universe of the very small, is very well understood. Without it, we wouldn't have understood the nature of materials or how electrons arrange themselves around atoms. We wouldn't have developed modern electronics. But you also need the narrative that goes with it, the story that explains: 'What does this mean, and how does it connect to the real world?' Quantum mechanics, for just

coming up to a century now, seems to have got away scot-free without having a unique way of explaining what the heck is going on. But I'm now of a generation where we've managed to finally break away from the old guard. We have now got to the stage where we can say, actually, that's not enough.

There are so many different interpretations of what quantum mechanics might mean. Which runner would you back in that race?
Now we are bordering on something akin to religious belief: do you belong to the many worlds school or the Bohmian school or the Copenhagen school or whatever? I'm agnostic. I do prefer what are called realist interpretations: that there is a real world out there, independently of what we might think. And I do believe there is a unique interpretation. Whether or not we will find it, I don't know, but it's out there. The universe doesn't care about the different ways we describe what's going on, but whatever it does, it does behave in a certain way.

Is our problem with quantum theory that we are missing a connection between mind and matter?
There were physicists like Eugene Wigner in the mid-20th century who gave credence very strongly to the idea that consciousness plays an important role in observing the quantum world. But I think there's something too magical and mystical for most physicists today to think the nature of consciousness and the human mind somehow has a bearing on the quantum world.

The sort of research I'm working on at the moment says that anything that behaves quantum mechanically doesn't do so in isolation; it's surrounded by an environment. And it is its surroundings that are looking at it, measuring it. There's something called decoherence, where the quantumness leaks out into the environment. So with the famous cat in the box paradox, where it's dead and alive at the same time, it doesn't make up its mind whether it's dead or alive once a human being with a consciousness or a PhD or a white lab coat opens the box to check it. Whatever quantumness has gone on there has decohered long before the box is open. But there is still this issue about where the boundary lies between the quantum world and our everyday classical world.

DAVID CLIFF/ANADOLU AGENCY VIA GETTY IMAGES

Scientists are getting increasingly involved in activism, like these climate protesters

One very specific area you have worked in is the role that quantum physics plays in life.
Yes, quantum biology. I first got into this probably a quarter of a century ago, and it's fair to say that even to this day, it's speculative and, in some sense, controversial. Partly, biologists don't know quantum mechanics, and they won't accept that quantum weirdness is going on inside their labs, while physicists find biology hard and complicated. They'd much rather do their experiments in a physics lab, rather than trying to understand what's going on inside a living cell where thousands of chemical reactions take place. And then the chemists who sit in between will say that of course everything, at some level, when you get down to atoms and molecules, is going to behave quantum mechanically.

But despite the fact that we should see quantum effects – dissipating and decohering very, very quickly – inside the warm, messy, noisy environment of a living organism, there's growing evidence in the last decade or two that life, over the course of billions of years, has evolved the ability to fine-tune things to maintain quantum effects for long enough that they can have some functional role to play inside living cells. Quantum mechanics isn't just going along for the ride: there are certain things – whether it's photosynthesis, whether it's mutations in DNA – that wouldn't happen, or wouldn't happen so efficiently, unless quantum mechanics is playing a role. What I find exciting is life is somehow different from inanimate matter of equivalent complexity, because life has evolved the trickery of the quantum world to make it more efficient.

If you had some words of advice for young people thinking of going into the life scientific, what would you say to them?
All children are curious, they ask all the "why" questions. Most people, when they grow up to adulthood, stop asking the why questions. You get on with life and all the problems and challenges that it throws at you. To be a scientist, you never lose that childlike curiosity about the world. If that's the sort of person you think you are, if that's what gets you going, being curious about the world, then you're already a scientist. ▮

The Joy of Science by Jim Al-Khalili is coming soon to the *New Scientist* shop

Richard Webb is executive editor of *New Scientist*

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Puzzles
Try our crossword, quick quiz and logic puzzle p53

***Almost* the last word**
Why is the first pancake of the batch the worst one? p54

Tom Gauld for *New Scientist*
A cartoonist's take on the world p55

Feedback
Scientists prove that boring people are boring p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

Stargazing at home

Planets for breakfast

Stargazing favours night owls, but here's a treat for early birds, says **Abigail Beall**, with a host of planets on the horizon

Abigail Beall is a feature editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

A clear view of the horizon
An alarm clock
Powerful binoculars or a small telescope (optional)
An astronomy app (optional)

STARGAZING is obviously a hobby best suited to night owls. The darkest skies that come in the middle of the night tend to provide the greatest number of astronomical opportunities. But every so often, early birds get a chance to make the most of being up before dawn, and this week we highlight one such opportunity.

In the last week of March and the first week of April, stargazers around the world will be able to see three planets close to each other in the sky in the hour or so before the sun rises. Saturn, Venus and Mars will appear in a triangle, close to the sliver of the crescent moon in the sky. Just look to the east before sunrise.

Exactly when these planets will appear and in what configuration depends on where you are in the world, but they will be closest together in the sky around 30 March. In the days leading up to this, for those in the northern hemisphere, Saturn will appear furthest to the east with Venus and Mars more towards the south. They will all be near the horizon. After 30 March, Saturn will move towards the middle of the triangle. Venus will be the brightest of the three, with Saturn and Mars much fainter in comparison. All three should be easy to spot with the naked eye.

You will need a clear view of the south-eastern horizon to catch the planets, away from trees or tall buildings. This is because they will be rising just before the sun, leaving a period of less than half an hour each day in which to spot them for most people, particularly those in the northern hemisphere. In some places, mainly in the southern hemisphere, there will be more time to catch them – at least an hour.

M-GUCCI/GETTY IMAGES

For those in the southern hemisphere, Jupiter will also make an appearance, trailing behind the other three planets at first but catching up to them by the second week of April.

Those in places far enough south to be able to see Jupiter while it is still dark might even catch a glimpse of its largest moons – Io, Europa, Ganymede and Callisto – through powerful binoculars or a small telescope. In most places, however, Jupiter will be rising too close to sunrise for them to be seen.

To plan what you want to spot, discover which times will be best to look or to check which planets you are seeing, use a stargazing app or astronomy software like Stellarium, which will let you know what you can expect to spot from where you live. Don't worry if you miss your first chances to view them – these planets will remain in the morning sky for most of April, too.

If you miss out entirely, fear not. Venus will be visible in the mornings until November, Saturn can be seen until August (when it becomes an evening planet) and Mars will be visible in the mornings until October, when it starts to rise in the evenings. ▮

These articles are posted each week at newscientist.com/maker

Stargazing at home appears every four weeks

Next week

Science of gardening

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- Support the efficient/effective operation of the CIPM Mutual Recognition Arrangement (CIPM MRA) by managing the work of KCDB Office/JCRB Executive Secretary;
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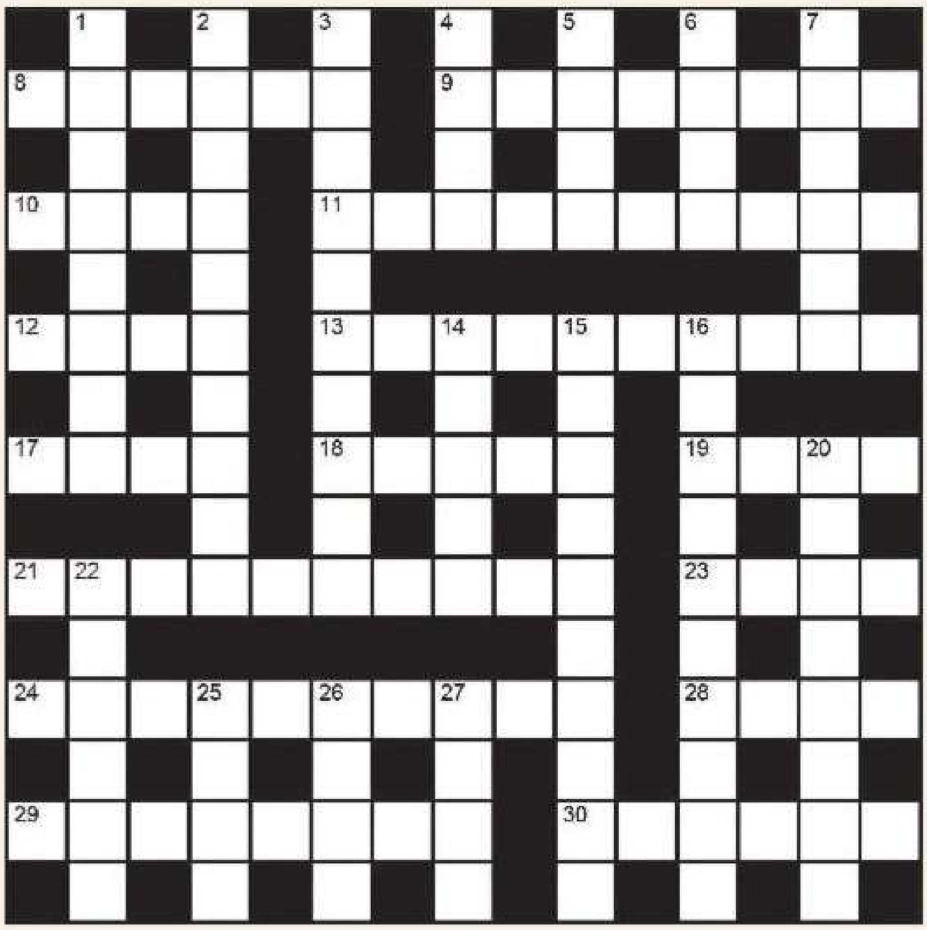
Quick crossword #104 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS
8 Part of the body between the neck and abdomen (6)
9 Tuberculosis (8)
10 Diminutive songbird (4)
11 Type of white blood cell (10)
12 John ___, Nobel prize-winning mathematician and economist (4)
13 The dog star (5,5)
17 Sac formed in tissue (4)
18 The sepals of a flower (5)
19 Vertical curved structure (4)
21 Downward movement of Earth's surface (10)
23 Hearing organs (4)
24 Automated weapon such as the Gatling or Maxim (7,3)
28 Long-distance explosive projectiles (initials) (4)
29 Part of the gut (8)
30 Greatly elevated (4-2)

DOWN
1 Chemist's shop (8)
2 Lung inflammation (10)
3 Substance produced by wood sorrels, $HO_2C{-}CO_2H$ (6,4)
4 Unwanted email (4)
5 Irritation; tickle (4)
6 Zn (4)
7 Linux distribution, informally (6)
14 Early synthetic material (5)
15 Fractions equal to 0.0625 (10)
16 1973 book by Oliver Sacks (10)
20 Largest part of the brain (8)
22 Seventh planet from the sun (6)
25 ___ Lamarr, actress and inventor (4)
26 Three squared (4)
27 ___ theory, field of mathematics pioneered by 12 Across (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #144

1 What unusual planetary feature did German astronomer Samuel Heinrich Schwabe observe in 1831?

2 Which armoured animals are of the order Cingulata?

3 The Great Pyramid of Giza was built for the second pharaoh of the Fourth Dynasty of ancient Egypt. What was his name?

4 The names of how many elements were derived from the village of Ytterby in Sweden?

5 In what year was the cryptocurrency bitcoin created?

Answers on page 55

Puzzle
set by Howard Williams
#160 Blurry-Ness

Click! The camera shutter opened and closed just as the creature's head ducked back beneath the surface of the lake, creating a large ripple.

"I got it! I finally got a picture of the Loch Ness monster!" exclaimed Lily. She looked at the result on her digital camera. "It's blurry!" She hung her head in defeat.

The boat passed directly over the spot where they saw the creature, but it was nowhere to be found. "How far away do you think it was when I took the picture?" Lily asked Amelia later that day.

"Well, we were travelling in a straight line at 2 metres per second towards where we saw Nessie, and it took us 5 seconds to reach that large ripple it created, and another 10 seconds to get to the other side of the ripple. So that means it was 5 seconds plus an additional 5 to the middle of the ripple, which would make it 20 metres!"

"Sadly, I think your maths is as fuzzy as my photo," said Lily.

How far away was the monster at the time the picture was taken?

Solution next week

First is worst

Whenever I cook a pikelet, pancake or fritter, the first batch tastes and looks worse than the rest. Why is this?

Susan Bell
London, UK
When you start to cook a batch of pancakes, you have to get the pan hot enough. People worry that they will burn the pan, so they put the mix in too early. The pancakes or fritters then absorb too much fat and go soggy.

When people see that the pancakes aren't cooking quickly enough, they turn the heat up a bit and the next ones are usually fine.

Stuart Farrimond
Author of The Science of Cooking, *Trowbridge, Wiltshire, UK*
There are two key reasons why the first pancake, fritter or pikelet is usually the worst of the bunch. The first is that heat hasn't yet evenly distributed across the surface of the pan when the first dollop of batter is added. The centre of the pan will invariably be hotter than the edges and there will be hot spots – especially with thin pans or with pans that are too big for the burner or hob.

Your first attempt will therefore be less evenly cooked than the next. By the time the first pancake, say, has been cooked, heat will be much more evenly distributed across the pan's base.

> "When cooking pancakes, pikelets or fritters , people worry that the pan will burn so they put the batter in too early"

Beware advice saying copper pans will avert this problem. While copper distributes heat across its surface faster than other metals do, it is the thickness of the pan's base that will have a larger effect on the evenness of the heat distribution, and a thick, cheaper pan can outperform a thin copper one.

The second and probably more important factor is due to the oil initially being unevenly spread across the pan's surface.

Frying is such an effective cooking technique because the oil transfers heat from the pan's surface into the food very efficiently, and at high temperatures, while forming a barrier between the food and the metal. This barrier prevents sticking – when protein binds directly to the metal's surface – and scorching, a chemical reaction called pyrolysis.

When oil is first added to a clean pan, it will invariably collect in small blobs across the surface, meaning it won't form an even oily veneer when the first dollop of batter is added to a pan.

After the first pancake has been cooked, however, the residual oil will be spread evenly across the now very hot pan, meaning the second will be much more successful.

A neat way to sidestep this is to use a piece of kitchen paper to wipe off nearly all the oil just before adding the first dollop of batter or fritter. Any blobs will be wiped away and a thin sheen of hot oil will be left behind.

John Winterburn
Earlswood, Warwickshire, UK
I have also found that the first pancake is the worst. It has a different texture and colouration to those cooked afterwards.

However, I find that the taste isn't affected and so the first pancakes are always treated as the cook's privilege.

CHAYANAN PHUMSUKWISIT/ALAMY

If the moon suddenly changed to green cheese, what difference would it make?

This week's new questions

Cutting it **How would prehistoric people have cut their toenails?** ***Emiel de Lange**, Berkel-Enschot, The Netherlands*

Moon swap **If the substance that the moon is made of was instantaneously changed to green cheese, what would the consequences be?** ***Richard Walker**, Royston, Hertfordshire, UK*

Fungal friends

Plants and fungi share highly developed symbiotic relationships, but do humans, or any other animal, enjoy similar beneficial relationships? Or is it all just itchy feet and flaky skin?

Peter Jackman
Llandysul, Ceredigion, UK
The human mycobiome, or fungal microbiome, consists of a variety of fungi including *Aspergillus*, *Candida*, *Saccharomyces*, *Cladosporium* and *Malassezia* that occur on human skin, in the mouth, gut and vagina. These fungi, which include yeasts, have generally been regarded as either commensal (living on us without causing disease) or as pathogens.

In reality, it is a sliding scale of effects. For example, the yeast *Candida albicans* is frequently found in the vagina after puberty and its effects seem to vary from infection through commensalism to symbiosis according to the person's health. Its presence can be symbiotic in preventing colonisation by *E. coli* bacteria from the gut, which can cause infection. Symbiotic relationships in the gut mycobiome are also a possibility.

Itchy feet are frequently blamed on fungal infections, but the culprit causing the most damage is most likely to be the bacterium *Brevibacterium epidermidis*. This is due to enzymes it releases, which break down proteins such as skin keratin.

Generally, our best symbiotic relationship with fungi seems to be when we keep them at arms length for production of fermented foods and drinks.

Garry Trethewey
Cherryville, South Australia
Looking out of my window, I see beans, lettuces, apples, apricots and grapes enjoying a symbiotic relationship with at least one

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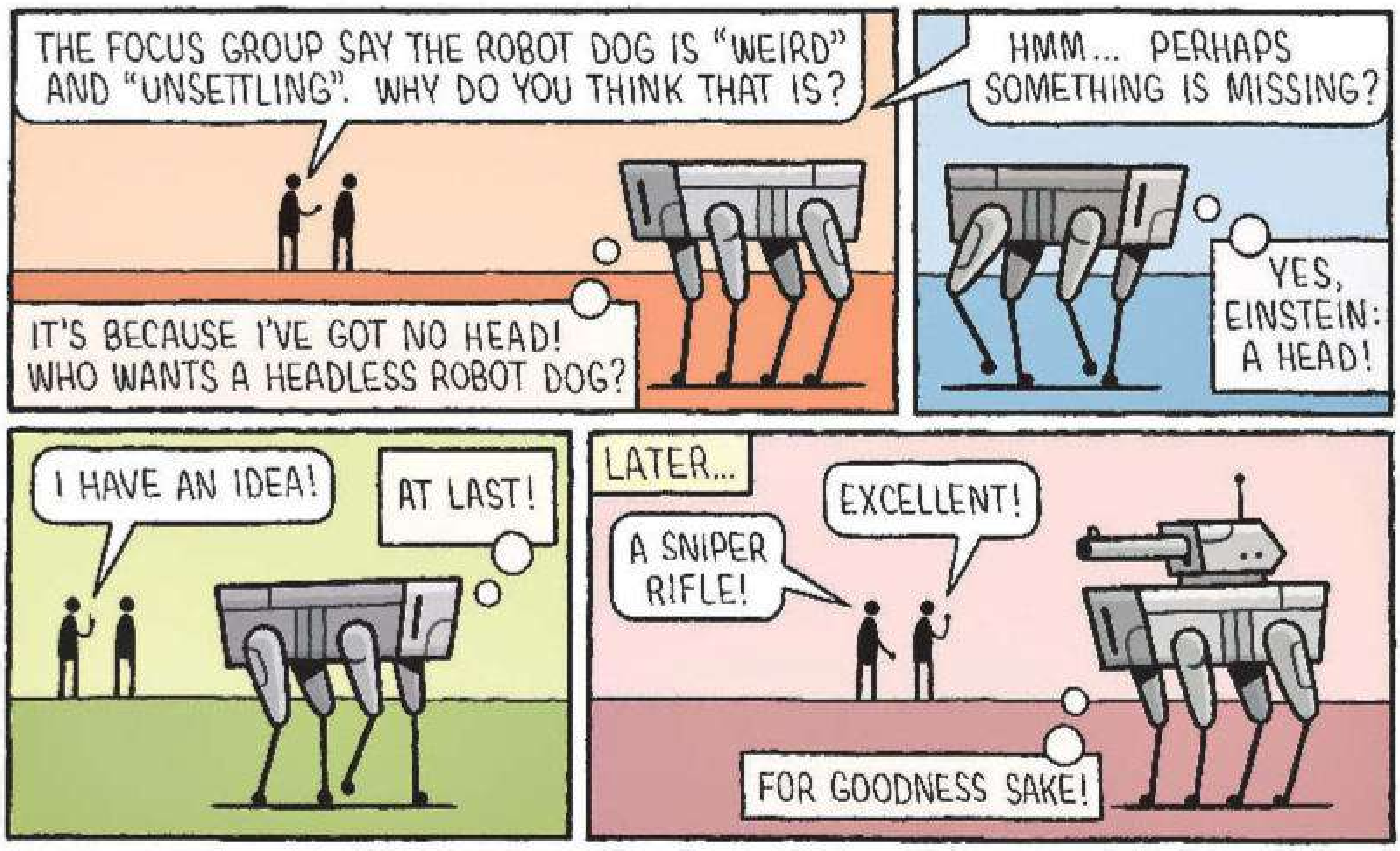
Tom Gauld
for New Scientist


THE FOCUS GROUP SAY THE ROBOT DOG IS "WEIRD" AND "UNSETTLING". WHY DO YOU THINK THAT IS?
IT'S BECAUSE I'VE GOT NO HEAD! WHO WANTS A HEADLESS ROBOT DOG?
HMM... PERHAPS SOMETHING IS MISSING?
YES, EINSTEIN: A HEAD!
I HAVE AN IDEA!
AT LAST!
LATER...
A SNIPER RIFLE!
EXCELLENT!
FOR GOODNESS SAKE!

human being. I work hard to make sure that they have an easy life, are well nourished, watered and free of predators. In return, they get eaten. There is some cost on both sides, but overall, a benefit to all.

None of those plants would have been as prolific before we entered into this Faustian bargain. My supermarket provides about six kinds of fungus that I can eat, courtesy of the same bargain.

As for other animals, leaf-cutter ants are famous for farming a fungus, feeding it with leaf segments, then eating it. Again, there is a cost on both sides – ants have to work, fungus gets eaten – but overall, there is a mutual benefit.

Factual evolution

When does a theory become a fact, and who decides? (continued)

Mark Wood
Bedford, UK
There is an underlying assumption in this question of there being a concrete "reality", for which a perfect description can be found. This perfect description would then be an indisputable fact. Some philosophers and scientists argue against this underlying assumption.

"There is an underlying assumption that there is a concrete 'reality' for which a perfect description can be found"

Particularly in the quantum world, reality is a somewhat fluid and difficult quality to pin down. Thus there would be no absolute "facts". All of science is a model, or theory, based on the best explanation we can think of so far for the most precise observations that we are currently able to make.

What makes one model better than another? Some will point to the elegance or even beauty of a particular theory, but the final arbiter ultimately always boils down to how accurately it matches the observations.

Mark Oliver
Ashburton, Victoria, Australia
I think there has been some confusion in the previous answers to this question because the word "science" is being used in two very distinct areas.

First, there is the science that enables us to observe the galaxies and our world more closely. This enables us to identify empirical facts. It is about what is happening.

Second, there is the science of prediction and explanation, which is a domain of scientific theory. It is about why something is happening.

Empirical observations can give us facts – and are the basis of scientific laws – but you can never prove a scientific theory. You can only disprove it.

There seems to be a worrisome move to believing that some scientific theories are true. This turns science into a belief system, a religion if you like, and stops people thinking, which is the very opposite of what science is trying to get us to do. ▮

Answers

Quick quiz #144 *Answers*

1 Jupiter's Great Red Spot
2 Armadillos
3 Khufu
4 Four: yttrium, erbium, terbium and ytterbium
5 2009

Cryptic Crossword #79 *Answers*

ACROSS 1 Rookie, **4** Gullet, **9** Mycenae, **10** Crown, **11** Lambs, **12** Airtime, **13** Star-studded, **18** Artists, **20** Scowl, **22** Hence, **23** Smidgen, **24** Swanky, **25** Wrench

DOWN 1 Ramble, **2** Occam, **3** Ioniser, **5** Ulcer, **6** Lionise, **7** Tenrec, **8** Metastasise, **14** Titania, **15** Dossier, **16** Lashes, **17** Flinch, **19** Sleek, **21** Organ

#159 Express coffee *Solution*

The location with the smallest combined distance is B.

Suppose the depot is lined up with the vendor that is fourth from the left (the "middle" vendor). If the depot is moved to the left of this, the combined distance of the three vendors to the left will reduce, but the combined distance for the four on the right will increase by the same amount, so the overall combined left-right distance will increase.

Similarly, if you align the depot with the vendor that is fourth from the top, any change in the vertical coordinate will increase the total distance.

Kim has realised that the depot should be in the horizontal and vertical position of the middle vendors in those two directions, which is B.

Not at all dull

Are we boring you? As we leaf listlessly through the paper "Boring People: Stereotype characteristics, interpersonal attributions, and social reactions" from Wijnand van Tilburg at the University of Essex, UK, and his colleagues, we feel the answer is probably "no". Although we will make a fair stab at it.

To get the oldest and best one out of the way first, the paper isn't about civil engineers. Boredom, we read, is often conceptualised as "the adverse experience of wanting but being unable to pursue satisfactory activity" – or, alternatively, being stuck at a party with someone who is doing their own conveyancing.

In a series of experiments – involving asking people in the UK what professions, hobbies and personality traits they associate with boring people, using those answers to invent very boring, middlingly boring and sparklingly unboring people, and asking other people how boring they would find those people – the researchers find that, in the main, we find boring people boring, don't like them and go out of our way to avoid them.

This is capital-s Science. We are especially intrigued by some of the occupations (busboy, graveyard watcher) and hobbies (sleeping, ant study, even "going to gales") that entered the mix, which confirm our suspicion that you shouldn't ask the Great British Public anything, or possibly everything.

Sad to say, the most boring professions are data analysis, accounting and tax/insurance, suggesting numeracy is considered an evil, if a necessary one. But what do we see here? Near the top of the chart of most unboring occupations are science and journalism.

On that basis, we are off the scale. The authors stress that the study only examined the stereotypes that people hold about boring and non-boring people, and the actual characteristics of boring people may differ. Codswallop. If someone will just unlock the stationery cupboard door, we have a lot more to say about that.

Twisteddoodles *for New Scientist*

THEY KEEP APPEARING AND EVOLVING. WE CAN'T KEEP UP
THIS NEW ONE IS SPREADING LIKE WILDFIRE. I DON'T UNDERSTAND IT
THE DEPARTMENT OF MEME RESEARCH
@twisteddoodles

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Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT
Consideration of items sent in the post will be delayed

Round in circles

Boring and delighting the planet in equal measure, meanwhile, is the question of whether there are more doors or wheels in the world, after a tweet from formerly dull and blameless Ryan Nixon from Auckland, New Zealand, went viral.

We wouldn't presume to enter the debates on whether a wheel can be a door (yes, it is why we keep getting stuck in the revolving ones) or a door a wheel (only if you lay it on its side, but please extract us first). But we are delighted to see the Burj Khalifa, one of our favourite measures of bigness, pop up as a character witness for the door side, because it has some 17,000 doors (including the world's two highest revolving ones – who knew?), but no wheels.

But then, just think of the number of wheelie suitcases it must contain. Taking a broader view, we will plump for the doors, on the basis that evolution hasn't yet seen fit to invent wheels, but things like doors seem to exist in abundance, both in nature and perhaps also in the wider cosmos, if you count black holes as one-way exits. On the whole, however, this is possibly a conversation that has gone on too long already.

Up, up and away

As we attempt to move swiftly on, Barry Cash waylays us with the Float-A-Poo dog waste disposal system, which "uses helium to float dog poo away forever". "Once your bag is filled, seal it with a tie and release," the website trills. "Avoid power lines, windmills, falcons and airports."

"I hope it's a joke," says Barry. "But in the mad world in which we live, I fear it isn't." We can – we think – confirm it is merely a prank box for enclosing an alternative gift. But on the basis the system might plausibly work, we fear it is only a matter of time before someone does invent it.

Giraffe attack

Far be it from Feedback to question, glancing nervously over our shoulder, the news values that made Mail Online the most-read newspaper website in the world. We don't read it and we don't know anyone who does. Nor do you, and you all sent us the same article last week purely because you ran across it accidentally while looking for something else.

Still, since the article is entitled "Asteroid half the size of a giraffe strikes Earth off the coast of Iceland – just two HOURS after it was discovered by astronomers", this pleases us immensely.

Freyja Burrill of Kendal, UK, wonders what fractions of African megafauna are doing raining down in such northerly climes, and whether moose or orca might be more appropriate. We can't answer on the planetary dynamics front, but we see that the largest mammalian fauna native to Iceland is the puny Arctic fox, which seems a pretty meh unit for anything.

Meanwhile, Craig Morris of Pietermaritzburg, South Africa – "home to many 2 x [Giraffa] camelopardalis units", as he puts it – is puzzled as to what a standard giraffe-slicing technique is. "Laterally, vertically, or axially, including a head and neck, one or two pairs of legs and/or the tail end…?".

We have locked horns with the related question of giraffe tessellation before, without success (13 February 2021). Let's instead celebrate the advances in near-Earth observation technology that gave us two HOURS warning. Time was when, if you saw anything half the size of a giraffe falling on your head, it was already too late. ▮

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